NORTHEAST FLOOD STUDIES

INTERIM REPORT
ON
REVIEW OF SURVEY

HOUSATONIC RIVER BASIN

UPPER NAUGATUCK RIVER
ABOVE
TORRINGTON, CONNECTICUT

Corps of Engineers, U.S. Army - Office of the Division Engineer

New England Division - Boston, Mass.

MAY 31, 1956

TABLE OF CONTENTS

TABLE OF APPENDIXES

SYLLABUS

The Division Engineer finds that experienced flood losses in the intensively developed upper Naugatuck River Valley are sufficient to justify reservoir protection for the Torrington area. He points out that the authorized Thomaston Dam and Reservoir, being located downstream of Torrington, provides no flood protection for that area.

He recommends construction of two dams and reservoirs on tributaries of the Naugatuck above Torrington at a total estimated cost to the United States of $3,740,000. He further recommends that local interests be required: (1) to provide, without cost to the United States, all lands, easements, and rights-of-way necessary for the construction and operation of the projects; and (2) to maintain the projects after completion. He further recommends that these reservoirs be constructed in the immediate future since uninterrupted operations of the brass and other metal manufacturing facilities of the valley are vital to the national economy.

SUBJECT: Interim Report for Flood Control, Housatonic River Basin, Upper Naugatuck River above Torrington, Connecticut

TO: Chief of Engineers
Department of the Army
Washington 25, D. C.
ATTENTION: ENGWF

1. AUTHORITY

This report is submitted pursuant to authority contained in Resolution of the Committee on Public Works of the United States Senate, adopted September 14, 1955:

> "The Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be and is hereby requested to review previous reports on the...Housatonic River, Connecticut... in the area affected by the hurricane flood of August 1955, to determine the need for modification of the recommendations in such previous reports and the advisability of adopting further improvements for flood control and allied purposes in view of the heavy damages and loss of life caused by such floods."

2. SCOPE OF SURVEY

2.1 Scope. - This interim report of survey scope for the Naugatuck River watershed above Torrington, Connecticut is submitted in partial compliance with 1st indorsement, dated 16 September 1955, from the Chief of Engineers to letter from the Senate Public Works Committee, dated 14 September 1955, subject, "Northeastern States Hurricane Flood Study."

This report is a review of flood problems in the Naugatuck River watershed in and above Torrington, Connecticut and makes specific recommendations in the interest of flood control.

2.2 Topographic Surveys. - Topographic work at potential dam sites consisted of field checking the topography of recent U.S. Geological Survey and U.S. Army Map Service sheets.

2.3 Subsurface Exploration. - Subsurface explorations have been conducted at two potential dam sites. Results of geologic and soils investigations are included in Appendix A.

2.4 Flood-Damage Survey. - Surveys of the flood damage were made after the floods of 1938, 1948, and 1955. The surveys consisted of personal interviews with municipal and state officials, officers of industrial concerns, and private individuals suffering damages. A summary of the flood-damage studies is presented in Sec. 10 and 11 of this report. Supporting data is given in Appendix B.

2.5 Conferences with Local Interests. - Special Act 52, November-December 1955 special session of the Connecticut General Assembly, appointed a Naugatuck Valley River Control Commission. Section 2 of the enabling act states "said Commission shall study in all its aspects the problem of flood control in the Naugatuck River Valley......shall cooperate with and correlate its efforts with Federal agencies in the same field and shall give all possible aid to the regional and municipal flood control."

The Commission has held meetings with Federal, State, and municipal agencies and with private citizens in order to formulate a flood-control plan for the valley. The Corps of Engineers aided in the work of the Commission and furnished data and technical assistance. Local interests and State agencies have written to express their approval and support of early construction of the improvements recommended in this report. Copies of these letters are attached as Appendix C.

3. PRIOR REPORTS

3.1 Published Reports. - Flood control on the Naugatuck River has been considered in the following reports on the Housatonic River:

House Document No.	Congress	Session	Date	Remarks
246	72nd	1st	Feb. 10, 1932	Preliminary report covering navigation, flood control, power development, and irrigation. Summarizes previous reports on the Housatonic River basin.
338	77th	1st	July 31, 1941	Reviews the previous report on the Housatonic River basin and recommends construction of Thomaston Reservoir.

3.2 Unpublished Report. - In the following unpublished report, the flood problem in the Naugatuck River watershed was treated as a part of the over-all problem in the Housatonic basin:

The Resources of the New England-New York Region prepared by the New England-New York Inter-Agency Committee

This report was prepared pursuant to directive contained in the Presidential Letter of October 9, 1950. This comprehensive report inventoried the resources of the New England-New York area and recommended a master plan to be used as a guide for the regional planning, development, conservation, and use of land, water, and related resources of the region; also included were proposals to reduce flood losses.

3.3 Reports of Other Agencies. - The Naugatuck Valley River Control Commission has issued an "Interim Report on the Problem of Flood Control on the Naugatuck River and Tributaries and Adjacent Streams" (March 1956). Various other reports by planning boards and other town and State agencies have been of value in determining experienced flood damage and suggesting methods of improvements.

4. DESCRIPTION

4.1 General. - The Naugatuck River, principal tributary of the Housatonic, is a rapidly flowing, non-navigable stream. The watershed, which lies wholly within the western part of Connecticut, is about 50 miles long with a maximum width of 12 miles and a total drainage area of 312 square miles. The drainage area at Torrington is approximately 50 square miles. The headwaters of the Naugatuck lie about 6 miles south of the Massachusetts line in the southeast corner of the town of Norfolk at an elevation of about 1,500 feet. Between the headwaters and Torrington, the river falls approximately 900 feet in about 13 miles. The general direction of flow is southerly, through Torrington, Thomaston, Waterbury, Naugatuck, Beacon Falls, Seymour, and Ansonia to Derby where the Naugatuck joins the Housatonic in its tidal reach, about 12.25 miles from Long Island Sound.

4.2 Geology. - The watershed is generally hilly with narrow valleys. The steeply inclined ridges of the upper valley are composed of folded schists, limestone, and quartzite with a thin overburden of glacial till (sand, gravel, and cobbles). Stratified deposits are found in terraces throughout the river bottom lands and along the sides of the valley. The hills and a large portion of the valleys are covered with second- and third-growth timber.

4.3 Tributaries. - The Naugatuck River above Torrington has two main tributaries, the West Branch and the East Branch. The larger West Branch drains approximately 35 square miles. Hall Meadow Brook, main tributary of the West Branch, drains approximately 15.7 square miles. The East Branch drains about 14 square miles. Both streams are sources of high runoff during periods of intense rain and during periods of snowmelt.

4.4 Area Maps. - The Naugatuck River and its watershed are shown on standard quadrangle sheets of the U. S. Geological Survey, scale of 1:31,680 and on standard quadrangle sheets of the U. S. Army Map Service, scale of 1:25,000. A map of the Naugatuck River watershed above Thomaston is included as Plate 1 of this report. Profiles of the Naugatuck River and its principal tributaries above Thomaston are shown on Plate 2.

5. ECONOMIC DEVELOPMENT

5.1 Population. - The upper Naugatuck River watershed had a population of approximately 31,500 in 1955, of which 28,000 are in the city of Torrington. The area has shown rapid growth in industrial development and enjoys a favorable location with respect to major markets.

5.2 Transportation. - The Torrington area is served by State Highways 4, 8, 25, and 72, and by a network of hard-surfaced and gravel roads. A branch line of the New York, New Haven & Hartford Railroad provides passenger and freight service for the entire Naugatuck River Valley from Derby to its terminus in Winsted.

5.3 Manufacturing. - The densely populated Naugatuck Valley is one of the key industrial concentrations in the United States. It is one of the most important non-ferrous metal manufacturing centers in the nation. From the valley's industries come about 40% of the country's brass and bronze industrial shapes and a large part of the aluminum, zinc, and copper products. Other important industries include clockmaking and the production of rubber footwear. The city of Torrington, located in the northern portion of the watershed where the East and West Branches join to form the Naugatuck River, is representative of the highly industrialized centers of the valley. The principal industries of the city include miscellaneous nickel-, silver-, and gold-plated products, sheet and rolled brass, castings, and various types of machinery and machine parts.

5.4 Waterpower. - The Naugatuck River has been developed for the generation of hydroelectric power, producing about 2,000 kilowatts at seven plants. There remains little undeveloped hydropotential in the Naugatuck River basin.

5.5 Water Supply. - The city of Waterbury utilizes the headwaters of the Shepaug and a branch of the Naugatuck as its water supply. The city of Torrington's water supply is obtained from Reuben Hart Reservoir on Hart Brook, a tributary of the West Branch. Several small dams on secondary tributaries impound water for industrial process purposes or as pondage for small power developments. A number of manufacturing plants use raw river water for industrial processes and cooling, returning the major portion of this intake to the river within a relatively short time.

5.6 Agriculture. - Agriculture in the upper Naugatuck watershed is confined to the narrow valley floors. Adverse topography and soil conditions preclude any substantial expansion. A comparatively short growing season limits the types of corps. The principal agricultural products of the area are potatoes, corn, hay, tobacco, and grain.

6. CLIMATOLOGY

Average monthly temperatures in the Naugatuck River basin vary widely through the year with a mean annual temperature of approximately 47°F. Mean monthly temperatures for Norfolk and Waterbury, Connecticut (U.S. Weather Bureau stations) are given in Table D-I of Appendix D.

Mean annual precipitation over the Naugatuck River watershed is approximately 50 inches, uniformly distributed throughout the year. The maximum annual was recorded in 1955, when 23.67 inches and 17.49 inches were observed during the months of August and October, respectively. Mean, maximum, and minimum annual precipitation at Norfolk and Waterbury are given in Table D-II of Appendix D.

Average annual snowfall in the watershed varies from about 35 inches near the coast to over 80 inches in the region of the headwaters.

7. RUNOFF AND STREAMFLOW DATA

The U.S. Geological Survey has published records of river stages and streamflows at three locations in the basin for various lengths of time since 1918. The records are generally good to excellent except during periods of ice, when they are fair. Streamflow records for the Naugatuck River watershed are given in Table D-III of Appendix D.

8. MAJOR FLOODS

8.1 Floods of Record. - The Naugatuck River basin has suffered six major floods in the past 30 years. The maximum, in August 1955, resulted from rainfall that preceded and accompanied hurricane "Diane". This rain, which averaged more than 13 inches in the upper watershed and 10 inches in the lower basin, fell on ground already saturated by more than 7 inches of rain during hurricane "Connie" the previous week. The resultant flood, estimated to reach 41,600 c.f.s. at Thomaston and 106,500 c.f.s. at Naugatuck, was approximately four times the size of the previous maximum flood of record. Major floods and their peak discharges are listed in Table D-IV of Appendix D.

8.2 Historic Floods. - There is no reliable information on historic floods on the Naugatuck. However, available records indicate that the flood of October 1869 was severe and that other serious floods occurred in 1888, 1896, and 1897.

9. STANDARD PROJECT FLOOD

A standard project flood for Torrington was developed as a demonstration flood to test the effectiveness of the proposed reservoirs. The peak discharge of the standard project flood at Torrington, below the confluence of the East and West Branches, was computed to be 35,000 c.f.s., 33% greater than the experienced flood in August 1955. The proposed reservoirs would reduce the August 1955 flood in Torrington from a peak of 25,000 c.f.s. to a peak of 14,200 c.f.s. Details of the standard project flood derivation are given in Section D6.2 of Appendix D.

10. EXTENT AND CHARACTER OF THE FLOODED AREA

The city of Torrington, where the East and West Branches join to form the Naugatuck River, is the major damage center in the upper Naugatuck watershed. The towns of Litchfield (population 4,964) and Harwinton (population 1,858), south of Torrington, have also suffered heavy damage from past floods.

Much of the industrial expansion and urban growth has followed the pattern of locating in the narrow valleys of the principal waterways. Encroachment on the streams by this growth has further increased the natural tendency to flooding and the resulting losses have been heavy. The most damaging floods prior to the record flood of August 1955 were those of 1938 and 1948. In the flood of 1938 large portions of the industrial, commercial, and residential areas of Torrington were flooded and heavily damaged. The flood of 1948, although causing less severe damage than that of 1938, followed a similar pattern and the city again experienced heavy losses. The flood of August 1955 not only brought much greater damage to these same areas but also involved residential, commercial, and industrial properties previously unaffected and caused severe disruption of transportation facilities and utilities.

11. FLOOD DAMAGES

11.1 Flood Losses. - The flood of 1938, the second most damaging flood in the Torrington area, caused damages amounting to $130,000. In the flood of 1948, the city of Torrington was hard hit, suffering almost all of the $195,000 loss in the area. In August of 1955, disastrous flooding occurred along the East and West Branches and the main stem of the Naugatuck River. The damage caused by this flood was unparalleled in the history of the watershed. In the area extending downstream from the proposed dam sites on Hall Meadow Brook and East Branch south through Torrington, Harwinton, and Litchfield to the upstream limit of the authorized Thomaston Reservoir area, the 1955 flood took six lives and caused losses of $23,300,000.

A recurrence of the floods of 1938 and 1948 in the Torrington area under conditions existing in 1955 would cause damages amounting to $364,000 and $273,000, respectively. Almost all of the damage caused by major floods in the upper basin occurred below the proposed dam sites. Storage provided by these projects would effect an appreciable reduction on downstream flood stages.

11.2 <u>Classification of Losses.</u> - Over 96% of the 1955 flood damage in the upper portion of the Naugatuck watershed was experienced in the industrial center of Torrington. As in other areas in the valley, bridges became clogged with debris and were converted into temporary dams. As a result, the impounded water inundated widespread areas to great depths. Much of the damage in the plants of the Torrington Division of the American Brass Company, which suffered one of the heaviest individual losses in the city, can be traced to this condition. Most of the industrial damage, which amounted to over 40% of the total loss in the city, was experienced by six large concerns. The swift, destructive currents and heavy silting caused extensive stock, equipment, and structural damages in each of these industries.

Severe damage was also inflicted upon residential and commercial property. A total of 483 dwellings was damaged, of which 10 were destroyed. Over 250 commercial establishments suffered losses, ranging from flooded basements to complete loss of equipment and stock and, in six instances, the total destruction of the buildings. Damage to public utilities, highways, roads, and sewer and water lines accounted for the remaining 13% of the loss. Equipment of the telephone and power companies was hard hit. Seven bridges were washed away and four others damaged, and large sections of 11 different roads throughout the city were washed out.

11.3 Average Annual Losses. - For the purpose of economic study and comparison of benefits to cost, estimates of recurring flood losses have been converted to an annual basis. The average annual loss in the Torrington area as a whole amounts to $459,500. Along the West Branch below the Hall Meadow site to the Naugatuck confluence, losses amounted to $252,000, and below the East Branch site losses amounted to $65,200. The remaining $142,300 annual loss was experienced along the main stem of the Naugatuck River in the area extending from the confluence of the East and West Branches to the upper end of the proposed Thomaston Reservoir area. The estimates of annual losses have been derived in accordance with the standard practice of the Corps of Engineers of correlating stage-damage, stage-frequency, and damage-frequency relationships. Details of the derivation of losses and annual benefits are given in Appendix C.

12. EXISTING CORPS OF ENGINEERS' FLOOD-CONTROL PROBLEM

There are no existing Corps of Engineers' flood-control projects or local protection works in the Naugatuck River watershed above Torrington, Connecticut. The only authorized project in the basin is the Thomaston flood-control dam and reservoir located in the town of Thomaston, downstream from Torrington.

13. IMPROVEMENTS BY OTHER FEDERAL AND NON-FEDERAL AGENCIES

There are no existing flood-control improvements in the Naugatuck River basin. Stillwater Dam and Reservoir is located on the West Branch immediately below the confluence of the West Branch and Hall Meadow Brook. This reservoir, privately owned and operated by the American Brass Company for process water and power, provides no flood storage. In addition to Stillwater Dam and Reservoir, several smaller ponds exist for public and private water supplies. The nature and size of these ponds precludes their integration into an upper-valley flood-storage system.

14. IMPROVEMENTS DESIRED

The Naugatuck Valley River Control Commission has held several open meetings to systematically examine local flood-control desires and needs. As a result of these meetings and after coordination with technical advisory groups and Federal and State agencies, a well conceived flood-control plan for the area has been evolved. In its report, "Comments on the Report of Dam Studies Made under the Direction of the Corps of Army Engineers on the Principal Tributaries of the Naugatuck River Basin" (May 1956), the Commission strongly endorses construction of the Hall Meadow Brook and East Branch Dams. Local interests and State agencies are also strongly in favor of construction of these two projects as is evidenced by the letters of concurrence appearing in Appendix C of the report. Representatives of the Corps of Engineers participated in meetings arranged by the Commission.

15. FLOOD PROBLEMS AND SOLUTIONS CONSIDERED

15.1 Flood Problems. - The disastrous August 1955 flood in Torrington had three primary causes: (1) unprecedented rainfall in the upper watershed upon ground saturated by an earlier storm; (2) inherently poor channel hydraulics; and (3) insufficient natural valley storage in the upstream reaches. The channel through the city is restricted by buildings, dams, and bridges. These permitted formation of debris dams with resulting increase in flood levels. The hydraulic characteristics of the channel with the depth of the overbank flooding produced velocities which were governed by the over-all slope of the river rather than by localized hydraulic gradients.

Prevention of similar flooding will require adequate regulation to maintain a flow consistent with the capacity of the channel. With stream flows adequately regulated, high flood peaks and excessive velocities would also be controlled.

15.2 Solutions Considered. - Several methods and combination of methods for protecting the area from damaging floods have been considered. Among these was a program to deepen, straighten, and widen the channel of both branches through Torrington. This would require extensive excavating, and building dikes and flood walls, The excessive cost and dislocation caused by such work in the built-up urban areas precluded further consideration of this program.

A proposal to raise the existing Stillwater Dam to provide flood-control storage was also studied. Raising the reservoir would inundate extensive residential developments, and the cost of real estate acquisitions alone indicated this plan would not be feasible.

The most feasible solution to the flood-control problem in Torrington appears to be construction of flood-control dams and reservoirs on tributaries of the Naugatuck River above Torrington. Reservoirs on the smaller tributaries of the Naugatuck River above Torrington were first considered. However, most of the feasible sites were already occupied by water supply reservoirs, and the remaining potential sites would leave too large a drainage area uncontrolled to provide the required flood reductions in Torrington. Two dams on principal tributaries of the Naugatuck River above Torrington, as described in the following paragraphs, appeared to be the best solution.

16. FLOOD-CONTROL PLAN

16.1 General. - The improvements considered most feasible for the Naugatuck River basin above Torrington are two flood-control reservoirs, Hall Meadow Brook Dam and Reservoir and East Branch Dam and Reservoir.

16.2 Hall Meadow Brook Dam and Reservoir. - The Hall Meadow Brook dam site is located in the city of Torrington on Hall Meadow Brook, 0.4 mile above its confluence with the West Branch of the Naugatuck River. The reservoir would lie in the city of Torrington and the town of Goshen. The total drainage area of Hall Meadow Brook is 15.7 square miles. The drainage area at the dam site is 12.2 square miles. The project would consist of a rolled earth-fill dam 55 feet high and 1,080 feet long with a spillway located in a saddle in the left abutment. The capacity of the reservoir at spillway crest elevation of 890 feet mean sea level would be 7,200 acre-feet, equivalent to 11.1 inches of runoff from the tributary drainage area.

The project would require acquisition of approximately 465 acres of land and 17 sets of buildings and relocation of about 2.3 miles of secondary highway and 3 miles of utilities.

A cost estimate of the principal features of this project is shown in Table I. Details of this project, together with a reservoir map and general plan and details of the dam are given in Appendix E.

16.2.1 Spillway Design Flood. - Channel and valley storage in Hall Meadow Brook is very small and runoff is rapid. The spillway design inflow to the reservoir was computed to be 33,000 c.f.s., equivalent to 2,700 c.f.s. per square mile of drainage area. This was derived from hydrological records and by analyzing floods of record. Details of the derivation are given in Appendix D. The spillway design discharge is 25,000 c.f.s. with 10 feet of surcharge. The spillway capacity is designed to handle the spillway design discharge routed through the reservoir assuming that 8 inches of the flood-control storage was utilized at the beginning of the spillway design flood.

16.2.2 Outlet. - The outlet consists of a 45-inch diameter, ungated concrete conduit founded on bedrock. With the reservoir filled to spillway crest, the outlet discharge will not exceed downstream channel capacities; however, normal stream flows will pass without appreciable pondage.

16.3 East Branch Dam and Reservoir. - The East Branch dam site is located in the city of Torrington on the East Branch of the Naugatuck River, 3.0 miles above its confluence with the West Branch. The drainage area at the dam site is 9.25 square miles. The total drainage area of the East Branch is 14.0 square miles. The project would consist of a rolled earth-fill dam 95 feet high and 886 feet long with a side-channel spillway in the right abutment of the dam. The capacity of the reservoir at spillway crest elevation of 871 mean sea level would be 5,150 acre-feet, equivalent to 10.5 inches of runoff from the tributary drainage area.

The project will require acquisition of approximately 235 acres of land and 47 sets of buildings and relocation of 2 miles of a secondary highway and 3 miles of utilities.

Details of this project, together with a reservoir map and general plan of the dam, are given in Appendix E. A cost estimate of the principal features is shown in Table II.

16.3.1 Spillway Design Flood. - Channel and valley storage in the East Branch of the Naugatuck is small and runoff is rapid despite the general forest cover in the area. The spillway design inflow to the reservoir was computed to be 25,000 c.f.s., equivalent to 2,700 c.f.s. per square mile of drainage area. This was derived from hydrological records and by analyzing floods of record. Details of the derivation are given in Appendix D. The spillway design discharge is 22,000 c.f.s., with 10 feet of surcharge. The structure is designed to handle the spillway design discharge assuming that 8 inches of the flood-control storage was utilized at the beginning of the spillway design flood.

16.3.2 Outlet. - The outlet consists of a 38-inch diameter, ungated concrete conduit founded on bedrock. With the reservoir filled to spillway crest, the outlet discharge will not exceed downstream channel capacity; however, normal stream flows will pass without appreciable pondage.

17. MULTIPLE-PURPOSE FEATURES

Hall Meadow Brook and East Branch Dams and Reservoirs will be operated solely for flood control and no provisions are made for multiple-purpose features.

18. RECREATIONAL DEVELOPMENT

The Naugatuck River rises in attractive hill and lake country to the east of the main stream, but a large part of its course is through industrial communities where heavy pollution precludes recreational development. The greater part of the basin, however, is still rural in character. For the heavily populated industrial areas closely adjoining it to the east and south, the valley offers a ready escape from the urban scene, with opportunities for swimming, picnicking, camping, fishing, small-game hunting, canoeing, skiing, and touring in a countryside where natural beauty has been enhanced by attractive towns and villages. Since the reservoirs will be empty except during periods of high runoff, their construction would neither add to, nor detract from the present recreational values of the area. Consideration was given to the maintenance of a small pool for recreational or aesthetic purposes but due to the existence of numerous ponds in this area, there is little need for additional facilities of this kind, and local interests indicated they would prefer a "dry" dam. A preliminary report by the U. S. Fish and Wildlife Service, concurring in construction of the proposed dry dams, is included as Exhibit 3 of Appendix C.

19. ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES

19.1 General. - Estimates have been prepared on the basis of provisions of existing Flood Control Acts except that local interests will be required to provide all lands and rights-of-way necessary for the construction and operation of the projects and maintain the projects after completion. Unit prices used in estimating costs are based upon actual bids received for similar work in the same general region revised to 1956 price levels. Annual charges are based on an interest rate of 2.5% with amortization of the project cost to be distributed over a 50-year period.

19.2 Hall Meadow Brook Dam and Reservoir. - The estimated Federal first cost is $1,960,000 with the Federal annual charges estimated at $71,000. Non-Federal first costs for lands and easements are estimated at $460,000 with annual charges of $29,000, including tax losses estimated to be $9,000. The total project first cost is $2,420,000 and the total project annual charges are $100,000. A summary of the first costs and annual charges for the project is shown in Table I. Detailed costs are shown in Table E-I of Appendix E.

TABLE I

FIRST COSTS AND ANNUAL CHARGES

HALL MEADOW BROOK DAM AND RESERVOIR
(1956 Price Level)

FEDERAL INVESTMENT

Relocations	$ 470,000	
Reservoir	50,000	
Access Road	6,000	
Dam	1,156,000	
Engineering and Design	186,000	
Supervision and Inspection	92,000	
Total Federal First Cost	$ 1,960,000	
Interest During Construction	50,000	
Total Federal Investment	$ 2,010,000	

FEDERAL ANNUAL CHARGES

Interest on Federal Investment	$ 50,000	
Amortization	21,000	
Total Federal Annual Charges		$ 71,000

NON-FEDERAL INVESTMENT

Lands, Easements, and Rights-of-way	$ 460,000	
Total Non-Federal First Cost	$ 460,000	
Interest During Construction	10,000	
Total Non-Federal Investment	$ 470,000	

NON-FEDERAL ANNUAL CHARGES

Interest on Non-Federal Investment	$ 12,000	
Amortization	5,000	
Net Loss of Taxes	9,000	
Maintenance	3,000	
Total Non-Federal Annual Charges		29,000
TOTAL PROJECT ANNUAL CHARGES		$ 100,000

19.3. East Branch Dam and Reservoir. - The estimated Federal first cost is $1,780,000 with the Federal annual charges estimated at $64,000. Non-Federal first costs for lands and easements are estimated at $890,000, with annual charges of $38,000 including tax losses estimated to be $4,000. The total project first cost is $2,670,000 and the total project annual charges are $102,000. A summary of the first costs and annual charges for the project is shown in Table II. Detailed costs are shown in Table E-II of Appendix E.

20. ESTIMATES OF BENEFITS

The operation of the Hall Meadow Brook and East Branch Dams and Reservoirs would reduce flood damages along the Naugatuck River downstream of the projects. The majority of these benefits would be realized in the area above the Thomaston Reservoir. However, some additional benefits would be realized downstream of the Thomaston Reservoir in the larger and more infrequent floods. The computed project benefits are based on the difference between losses under present conditions and losses estimated for conditions after completion of the project. The average annual benefits for these projects are estimated at $244,000 for Hall Meadow Brook Dam and $128,000 for East Branch Dam. These benefits have been derived in accordance with standard practices of the Corps of Engineers. A discussion of the method and its application in determining the benefits for these two projects is contained in Appendix B.

TABLE II

FIRST COSTS AND ANNUAL CHARGES

EAST BRANCH DAM AND RESERVOIR
(1956 Price Level)

FEDERAL INVESTMENT

Relocations	$ 370,000	
Reservoir	11,000	
Access Road	6,000	
Dam	1,120,000	
Engineering and Design	183,000	
Supervision and Inspection	90,000	
Total Federal First Cost	$ 1,780,000	
Interest During Construction	40,000	
Total Federal Investment	$ 1,820,000	

FEDERAL ANNUAL CHARGES

Interest on Federal Investment	$ 45,000	
Amortization	19,000	
Total Federal Annual Charges		$ 64,000

NON-FEDERAL INVESTMENT

Lands, Easements, and Rights-of-way	$ 890,000	
Total Non-Federal First Cost	$ 890,000	
Interest During Construction	20,000	
Total Non-Federal Investment	$ 910,000	

NON-FEDERAL ANNUAL CHARGES

Interest on Non-Federal Investment	$ 23,000	
Amortization	9,000	
Net Loss of Taxes	4,000	
Maintenance	2,000	
Total Non-Federal Annual Charges		$ 38,000
TOTAL PROJECT ANNUAL CHARGES		$ 102,000

21. COMPARISON OF BENEFITS AND COSTS

21.1 Hall Meadow Brook Dam and Reservoir. - The total annual benefits from the proposed project are $244,000 and the total annual charges are $100,000. The ratio of benefits to cost is 2.4 to 1.

21.2 East Branch Dam and Reservoir. - The total annual benefits from the proposed project are $128,000 and the total annual charges are $102,000. The ratio of benefits to cost is 1.3 to 1.

22. PROPOSED LOCAL COOPERATION

The effect of the proposed reservoirs in reducing flood damages is concentrated largely in the city of Torrington and along the short reach of river above the authorized Thomaston Reservoir; although a smaller part of the benefits will accrue generally to downstream areas. Thus, the reservoirs are in effect local flood protection projects for which, under existing flood control law, local contribution is required.

It is considered, therefore, that even though these are reservoir projects with some general effect, local interests should participate to a reasonable extent in their costs.

In arriving at an equitable sharing of cost for these reservoirs, consideration was given to the fact that the city of Torrington suffered exceptionally heavy damage during the 1955 flood; and that the City has already expended some $800,000 in land acquisition, removal of buildings, and channel enlargement, in an effort to improve the floodway through the City. It was concluded, therefore, that a reasonable approach to sharing the cost would be to require non-Federal interest to provide all lands and rights-of-way required for construction and operation of the projects, and to maintain the projects after completion.

The city of Torrington and other local interests in the immediate area, while fully supporting the need for the proposed reservoirs, have questioned their ability to participate further in the cost of the work. The Governor of Connecticut, however, has advised this office of the interest of the State in the proposal and has stated informally that he is prepared to ask the Legislature for funds for this purpose, should such participation be required under the authorizing legislation.

23. COORDINATION WITH OTHER AGENCIES

It is the established policy of the Corps of Engineers to coordinate with Federal and state agencies and local organizations which have interests in the projects. The Federal agencies contacted in regard to the construction of Hall Meadow Brook or the East Branch Dams and Reservoirs are; The Department of Health, Welfare and Education; Fish and Wildlife Service; and the Federal Power Commission. Letters from the Fish and Wildlife Service and the Federal Power Commission concurring in the projects are included in Appendix C. The agencies contacted have been requested to conduct studies and to submit recommendations which will be considered in the over-all dam and reservoir plan. Interested State and local agencies in the area have also been contacted and asked for their comments on the projects. Letters from the Mayor of Torrington, the Naugatuck Valley River Control Commission, the Torrington Flood and Erosion Board, the Connecticut State Flood Control and Water Policy Commission, and the Connecticut State Highway Department indorsing the projects are included in Appendix C. These projects do not conflict with the overall basin plan as recommended in the report on the Resources of the New England-New York Region prepared by the New England-New York Inter-Agency Committee.

24. DISCUSSION

24.1 Need. - Flood protection is urgently needed for the Torrington area and that portion of the Naugatuck upstream from the authorized Thomaston Dam and Reservoir. Six major floods have occurred in the Naugatuck River basin in the past 30 years. In the most disastrous of these floods - that of August 1955 - entire blocks of buildings along the river bank were leveled. Industrial damage was extremely large, but damage to residential and commercial property was even greater. A total of 483 dwellings were damaged. Ten of these were completely destroyed; seven bridges were scoured out and washed away, and four others damaged. Debris covered approximately 50 miles of city streets, and sections of 11 different roads were washed out.

24.2 Plan of Improvement. - The most feasible plan for reducing flood losses in the Naugatuck River basin in Torrington and above is construction of flood-control reservoirs augmented by a limited amount of diking, floodwalls, channel re-alignment, and dredging in highly developed areas to supplement work now being accomplished by the City.

Remaining work for flood control in the Torrington area will be considered in a forthcoming report. This interim report is limited to consideration of the pressing need for upstream flood control reservoirs. Benefits to be realized from operation of Hall Meadow Brook Reservoir are estimated to be $244,000 annually. The estimated annual benefits from operation of East Branch Reservoir are $128,000.

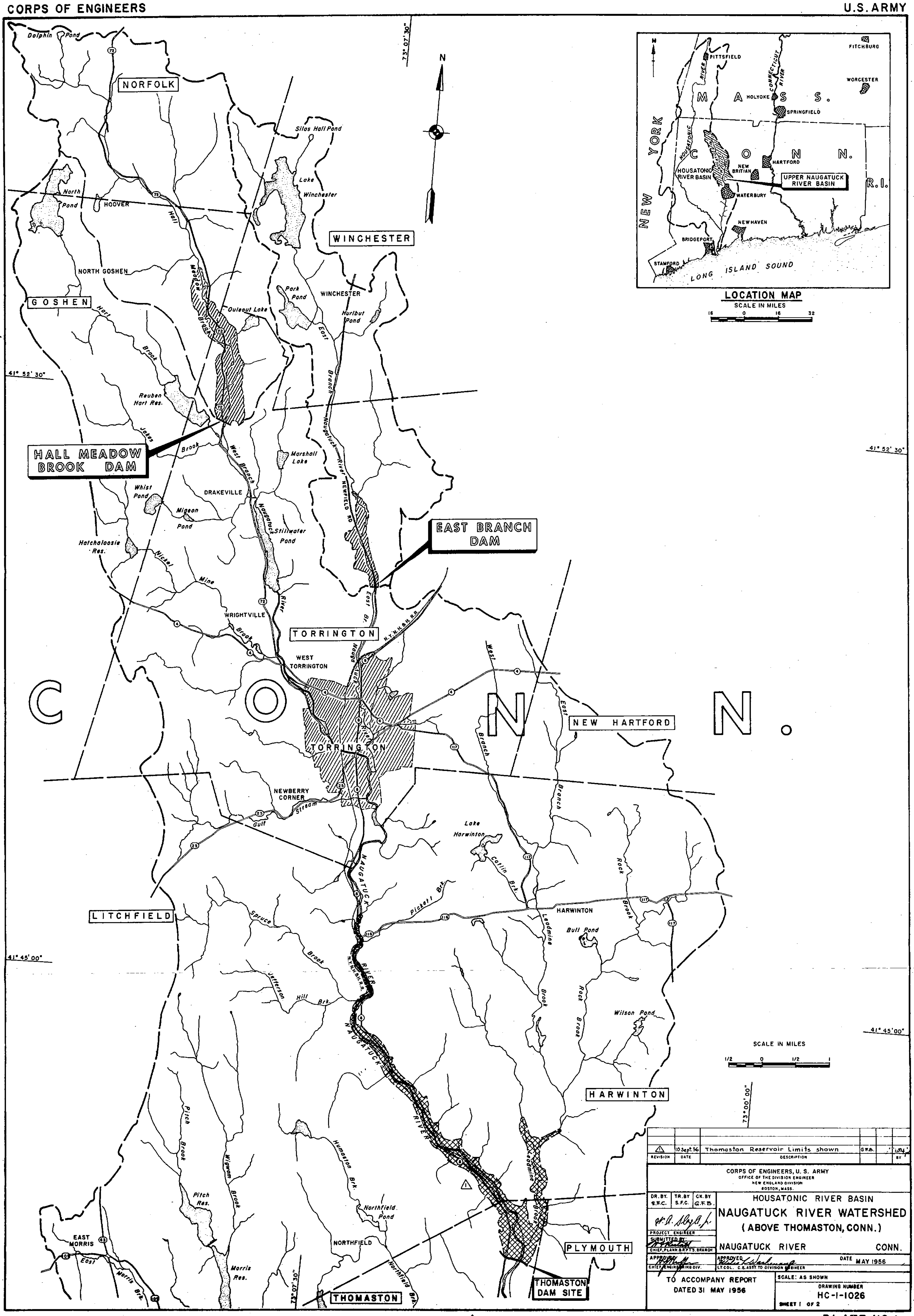
25. CONCLUSIONS

It is concluded that there is ample economic justification for a flood-control dam on Hall Meadow Brook and on the East Branch of the Naugatuck River. Benefits attributable to the two dams exceed the costs in a ratio of 2.4 to 1 for Hall Meadow Brook and 1.3 to 1 for the East Branch. The frequency of major storms, the rapid growth in the area, and the existing high industrial concentration make immediate construction of these two dams imperative.

26. RECOMMENDATIONS

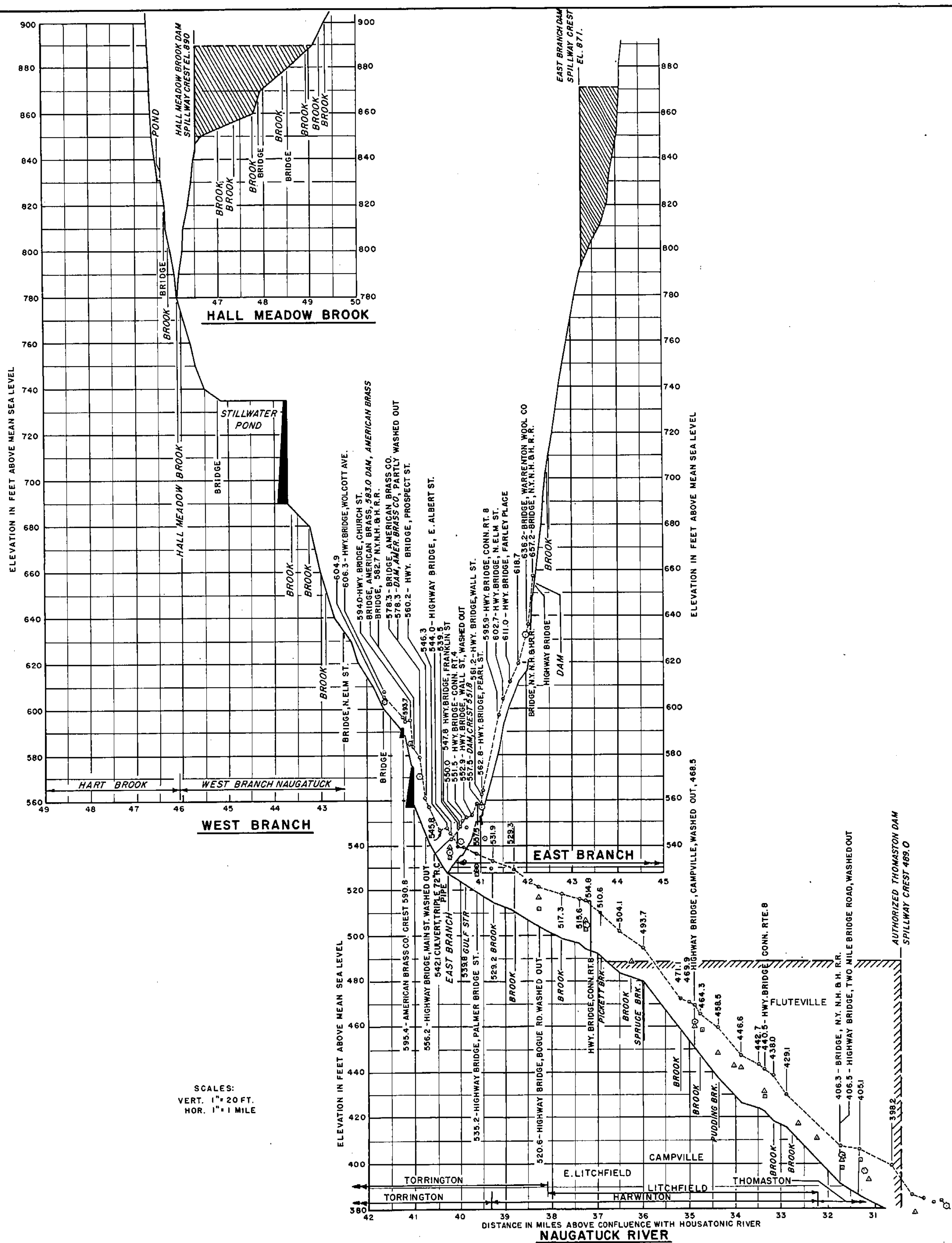
It is recommended that the plan for the control of floods in the Housatonic River basin, as contained in Flood Control Act approved December 22, 1944 (Public Law No. 534, Seventy-eighth Congress) as amended and supplemented, be modified to provide for the construction of a flood-control dam and reservoir on Hall Meadow Brook in Torrington and Goshen, Connecticut at an estimated first cost to the United States of $1,960,000 and a flood-control dam and reservoir on the East Branch of the Naugatuck River in Torrington, Connecticut at an estimated first cost to the United States of $1,780,000. It is further recommended that local interests be required to furnish all lands and rights-of-way necessary for construction and operation of the projects and to maintain the projects after completion.

ROBERT J. FLEMING, JR.
Brigadier General, U.S.Army
Division Engineer


NORFOLK
WINCHESTER
GOSHEN
TORRINGTON
NEW HARTFORD
LITCHFIELD
HARWINTON
PLYMOUTH
THOMASTON
C O N N.
HALL MEADOW BROOK DAM
EAST BRANCH DAM
THOMASTON DAM SITE
Dolphin Pond
Silas Hall Pond
Lake Winchester
North Pond
HOOVER
NORTH GOSHEN
Park Pond
WINCHESTER
Hurlbut Pond
Ouleout Lake
Reuben Hart Res.
Marshall Lake
Whist Pond
DRAKEVILLE
Mignon Pond
Stillwater Pond
Hatchaloosie Res.
WRIGHTVILLE
WEST TORRINGTON
NEWBERRY CORNER
Lake Harwinton
HARWINTON
Bull Pond
Wilson Pond
Northfield Pond
NORTHFIELD
Pitch Res.
Morris Res.
EAST MORRIS
41° 52' 30"
41° 45' 00"
73° 07' 30"
73° 00' 00"
SCALE IN MILES
1/2 0 1/2 1
LOCATION MAP
SCALE IN MILES
16 0 16 32
PITTSFIELD
FITCHBURG
WORCESTER
HOLYOKE
SPRINGFIELD
M A S S.
C O N N.
NEW YORK
R.I.
HARTFORD
NEW BRITIAN
HOUSATONIC RIVER BASIN
UPPER NAUGATUCK RIVER BASIN
WATERBURY
NEW HAVEN
BRIDGEPORT
STAMFORD
LONG ISLAND SOUND
10 Sept. 56 Thomaston Reservoir Limits shown G.F.B.
REVISION DATE DESCRIPTION BY
CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.
DR. BY. S.F.C.
TR. BY S.F.C.
CK. BY G.F.B.
PROJECT ENGINEER
SUBMITTED BY:
CHIEF, PLANN. & RPTS. BRANCH
APPROVED
CHIEF, ENGINEERING DIV.
HOUSATONIC RIVER BASIN
NAUGATUCK RIVER WATERSHED
(ABOVE THOMASTON, CONN.)
NAUGATUCK RIVER CONN.
APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER
DATE MAY 1956
TO ACCOMPANY REPORT DATED 31 MAY 1956
SCALE: AS SHOWN
DRAWING NUMBER HC-1-1026
SHEET 1 OF 2

CORPS OF ENGINEERS

U.S. ARMY



PROFILE LEGEND

342.0	HIGH WATER ELEVATIONS OF AUGUST 1955
--•--	HIGH WATER PROFILE OF AUGUST 1955
——	NORMAL WATER PROFILE OF 1955
□	1936 FLOOD HIGH WATER MARKS
△	1938 FLOOD HIGH WATER MARKS
⊙	1948 FLOOD HIGH WATER MARKS
	EXISTING DEVELOPMENT
	PROPOSED FLOOD CONTROL DEVELOPMENT

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY E.R.S. | TR. BY S.F.C. | CK. BY G.T.B.

PROJECT ENGINEER

CHIEF, R. & H. SECTION

SUBMITTED BY: CHIEF, PLANN'G & R'TS BRANCH

APPROVED: CHIEF, ENGINEERING DIV.

APPROVED: LT. COL. C.E. ASST. TO DIVISION ENGINEER

HOUSATONIC RIVER BASIN
NAUGATUCK RIVER WATERSHED
PROFILES
EAST & WEST BRANCH
NAUGATUCK RIVER
NAUGATUCK RIVER, CONN.

DATE MAY 1956

TO ACCOMPANY REPORT DATED 31 MAY 1956

SCALE: AS SHOWN

DRAWING NUMBER HC-1-1027

SHEET 2 OF 2

PLATE NO. 2

APPENDIX A

GEOLOGY

A1. HALL MEADOW BROOK DAM

A2. EAST BRANCH DAM

APPENDIX A

GEOLOGY

A2. EAST BRANCH DAM (Cont.)

APPENDIX A

GEOLOGY

APPENDIX A

GEOLOGY

A1. HALL MEADOW BROOK DAM

A1.1. GEOLOGY AND TOPOGRAPHY

A1.1.1 General. - Hall Meadow Brook is the largest of several streams which unite to form the West Branch of the Naugatuck River. The region drained by all these streams lies in the western highlands of Connecticut which are part of the New England Upland. It is a region of moderate relief with till-covered, steep, bedrock hills rising above narrow valleys which have been filled with glacial debris. The bedrock of the region consists of folded crystalline rocks, mostly schist and gneiss, of Paleozoic age.

A1.1.2 Description of Site. - The relatively wide valley at the site is partially obstructed by a hill which occupies a large part of the valley bottom. The present river channel occupies a narrow valley on the west side of the hill with a wide, swampy, flat-bottomed saddle extending eastward from the hill to the main valley wall. Immediately downstream from the site, Hall Meadow Brook flows in a narrow rock gorge. Bedrock also outcrops along the west side of the road and in the stream bed at the site. A large concentration of boulders occupies the flank of the hill which forms the right abutment of the dam.

A1.1.3 Surficial and Subsurface Investigations. - A reconnaissance of the site was made to examine general foundation conditions and to preliminarily determine the availability of borrow materials. Subsurface explorations consisted of 4 test borings. The locations of the borings are shown on Plate A-1. The borings were continuously drive-sampled in overburden, and bedrock, where encountered, was diamond-drill cored. Overburden samples from the borings were classified in accordance with the Unified Soils Classification System. The classification of overburden samples and a description of the bedrock cores recovered from borings is shown in graphic logs on Plate A-1. General relations between overburden and bedrock and a line indicating the assumed location of the bedrock surface are shown in the log profile on Plate A-2.

A1.2. FOUNDATION CONDITIONS

A1.2.1 Overburden. - The overburden at the dam site is generally thin, less than 20 feet, and consists of variable, silty, gravelly sand with boulders which occur scattered at the surface over most of the dam site. Boulders are particularly concentrated on the right abutment. At the dike site, the overburden appears to be less than 20 feet thick on the abutments but a deep, buried valley underlies the swampy, flat-bottomed saddle. The overburden in the buried valley is till which is overlain by silty sand and superficial organic deposits. The silty sand extends up the abutments where it rests directly on the bedrock.

A1.2.2 Bedrock. - Bedrock outcrops in the stream channel at the site. The bedrock is biotite mica schist with numerous granitic phases and granitized zones. The rock is generally fine-grained except for the granitic phases which are coarse. Examination of outcrops and cores shows that the rock is hard, strong, and durable.

A1.2.3 Ground Water. - Levels of subsurface water as indicated by observations in borings during drilling operations at the dam site, appear to be generally less than 10 feet in depth. Near the stream, the level of subsurface water is believed to be essentially at the bedrock surface. Observation in one boring indicating a depth to subsurface water of 9 feet corresponding to a depth of approximately 6 feet below the rock surface in the nearby stream bed is obviously not reliable. At the right abutment of the dike ground water is indicated by borings to occur at approximately 16 feet. In the flat, swampy valley bottom at the dike site and in the left abutment, the level of subsurface water is believed to be at, or close to, the ground surface.

A1.2.4 Leakage Conditions in Reservoir. - The reservoir upstream from the dam and dike sites is completely enclosed by bedrock ridges. There are no low or pervious saddles on the reservoir rim, and there will be no leakage through the perimeter ridges. A buried valley which occurs in the foundation at the dike site will be considered in design stage to effect control of seepage.

A1.3. CONSTRUCTION MATERIALS

A1.3.1 General. - The general availability and location of borrow materials for construction has been determined from limited reconnaissance of the reservoir and study of topography. No subsurface explorations for borrow materials have been made for this stage of investigations.

A1.3.2 Pervious Materials. - Limited quantities of pervious materials are available in the reservoir and in the valley upstream from the reservoir. Additional materials required for pervious sections of the embankment are available within a 4-mile haul distance of the site.

A1.3.3 Impervious Materials. - Materials for the impervious sections of the embankments can be obtained from deposits of till consisting of silty, gravelly sand which blanket the higher slopes in the reservoir. Specific location of a borrow area in the till is contingent only on finding a nearby hillside where rock is sufficiently deeply buried to permit development of an economical working face.

A1.3.4 Rock Fill and Riprap. - Rock for rock fill or riprap is available from structure excavations or quarries opened in the local bedrock. The numerous boulders which will be encountered in excavations in the right abutment of the dam would also be suitable for rock fill or riprap.

A1.3.5 Concrete Aggregates. - Coarse aggregates for concrete are available from commercial Connecticut trap-rock quarries at Torrington and elsewhere within a 20-mile railroad haul of Torrington. Fine aggregate materials can likewise be obtained from nearby commercial sources.

A1.4. CONCLUSIONS

The site appears suitable for construction of the proposed dam and dike. Both overburden and bedrock foundations at the site are adequate to support design loads without excessive settlement. Preliminary investigations indicate no apparent major problems regarding seepage through the foundations. All materials from excavations will be suitable for use in the embankment.

A2. EAST BRANCH DAM

A2.1. GEOLOGY AND TOPOGRAPHY

A2.1.1 General. - The region drained by the East Branch of the Naugatuck River is located on the New England Upland in the western highlands of Connecticut. It is a region of moderate relief through which the East Branch of the Naugatuck River flows in a relatively deep, steep-sided valley. The bedrock of the region consists of a series of folded crystalline rocks, generally schist and gneiss, of Paleozoic age.

A2.1.2 Description of Site. - The dam site is located at the upstream end of a narrow river reach where the valley is constructed between till-covered bedrock walls. The ground surface at the site is thickly strewn with boulders which rest on bedrock or till. A great concentration of boulders is noticeable immediately below an extensive area of outcropping bedrock high on the right abutment.

A2.1.3 Surficial and Subsurface Investigations. - Brief site reconnaissance was made to examine general foundation conditions and to determine in a preliminary way the availability of borrow materials. Subsurface explorations consisting of three test borings were made at designated locations. The locations of the borings are shown on Plate A-3. The borings were continuously drive-sampled in overburden and, where bedrock was encountered, the rock was diamond-drill cored. Overburden samples from borings were classified in accordance with the Unified Soils Classification

System. The classification of overburden samples and a description of bedrock cores recovered from borings is shown in graphic logs on Plate A-3. General relations between overburden and bedrock and a line indicating the assumed location of the bedrock surface are shown in the log profile on Plate A-4.

A2.2 FOUNDATION CONDITIONS

A2.2.1 Overburden. - The overburden at the site consists of till with numerous boulders. The till is composed generally of compact, silty, gravelly sand. On the left abutment, the overburden is generally less than 5 feet thick except in local pockets or troughs in the bedrock surface where up to 10 feet of overburden may occur. The thickness of the till cover on the right abutment is questionable. Although rock may be close to the ground surface on the entire abutment, it is probable that the overburden may be up to 40 feet thick near the bottom of the abutment, thinning out as the abutment rises to the bedrock outcrop at, or immediately above, spillway-crest elevation. The boulders on the ground surface form almost a continuous pavement over most of the site and are especially large and numerous on the high right abutment.

A2.2.2 Bedrock. - Bedrock outcrops in an extensive, steep face high on the right abutment. Other smaller outcrops may occur but, if present, are not easily distinguishable from the numerous boulders at the site.

The bedrock consists of pink to grey granite-gneiss with large included masses of biotite mica schist. In the schist, the biotite occurs in thick, felted stringers and zones. The rock is generally fresh and hard and sufficiently strong for structure foundations.

A2.2.3 Ground Water. - Levels of subsurface water as indicated by observations in borings during drilling operations are slightly above river level near the valley bottom and apparently well below the rock surface on the left abutment. Subsurface water levels are probably near the ground surface on the till-covered right abutment.

A2.2.4 Leakage Conditions in Reservoir. - The reservoir is completely enclosed by high, wide, bedrock ridges. There are no low saddles on the reservoir rim and leakage through the perimeter divides is impossible. There is a possibility of a buried valley in the rock under the lower part of the right abutment at the dam site. Seepage through such a valley, if it exists, can be controlled by embankment design.

A2.3 CONSTRUCTION MATERIALS

A2.3.1 General. - The general availability and location of borrow materials for construction has been determined from preliminary reconnaissance of the reservoir and study of topography. No subsurface explorations for borrow materials have been made for this stage of investigation.

A2.3.2 Pervious Materials. - Pervious materials for embankment construction are available from outwash-plain deposits and small terraces located within the reservoir. In the event that sufficient quantities of pervious materials are not available from these sources, extensive deposits of suitable materials can be found within 3 miles of the site.

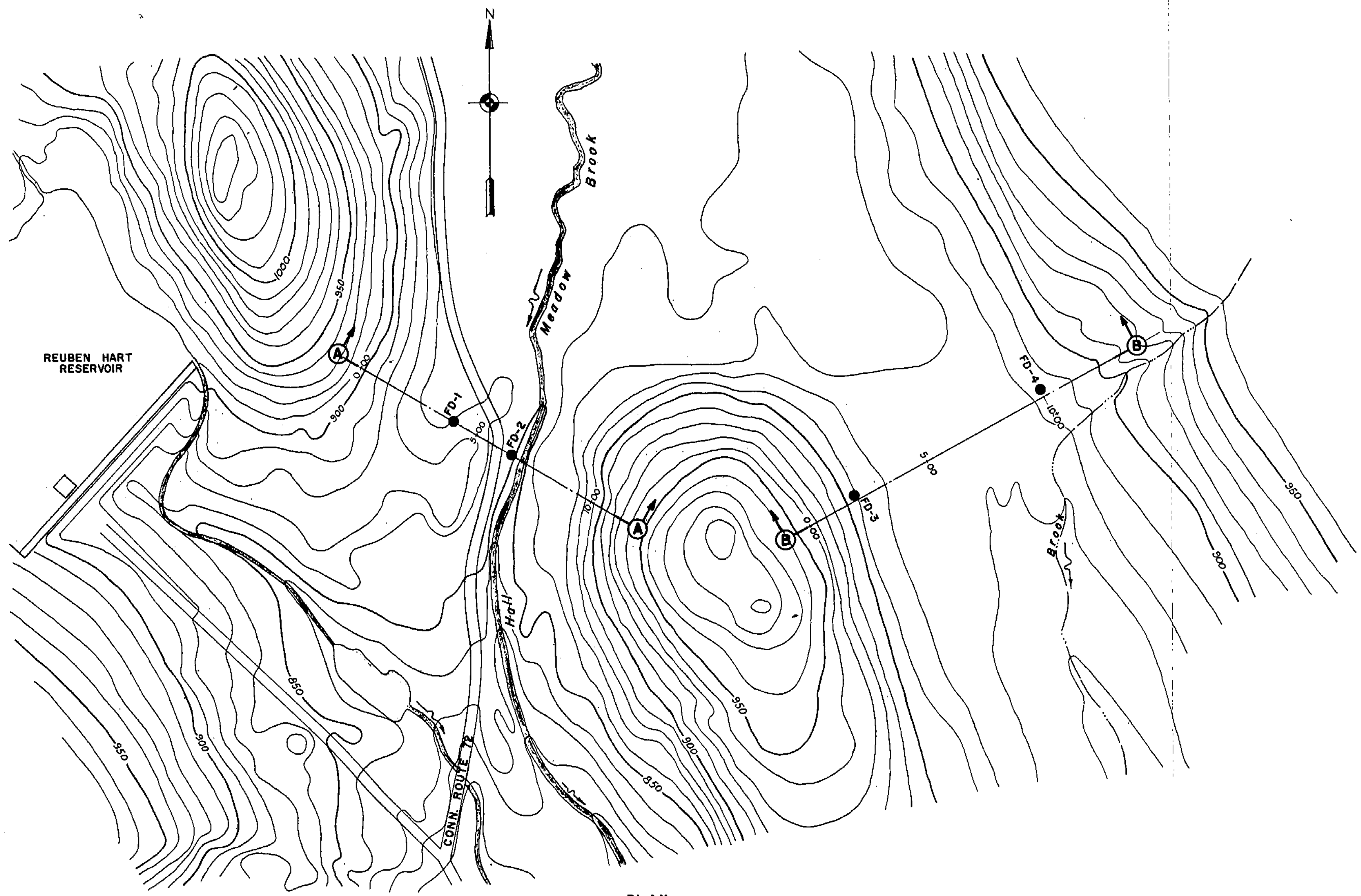
A2.3.3 Impervious Materials. - Impervious materials consisting of till are available on the hill slopes at, and adjacent to, the site. The till in the immediate vicinity of the site is very bouldery, but areas with fewer boulders could be found with 0.5 mile of the site.

A2.3.4 Rock Fill and Riprap. - Rock for riprap and rock fill is available from structure excavations and from the numerous boulders which occur at the site.

A2.3.5 Concrete Aggregates. - Coarse aggregates for concrete are available from commercial Connecticut trap-rock quarries at Torrington and elsewhere within a 20-mile railroad haul of the site. Fine aggregate materials can likewise be secured from nearby commercial sources.

A2.4 CONCLUSIONS

The site appears suitable for construction of the proposed dam. The materials at the site, both overburden and bedrock, are adequate to support design loads without excessive settlement. Preliminary investigations indicate no apparent major problems regarding seepage through the foundation. All material from excavations will be suitable for use in the embankment.



PLAN

SCALE IN FEET

200' 0' 200' 400'

NOTES:

Elevations refer to Mean Sea Level Datum.

Contour interval is 10 feet.

For Geologic-Log Sections, see Geology sheet.

Topography based on U.S. Geological Survey, West Torrington Quadrangle, Connecticut.

CORPS OF ENGINEERS, U.S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
R.V.F.	R.V.F.	HEB

HOUSATONIC RIVER FLOOD CONTROL

HALL MEADOW BROOK DAM

PLAN OF EXPLORATIONS

PROJECT ENGINEER

SUBMITTED BY:

CHIEF, PLANN. & ENG'G BRANCH

HALL MEADOW BROOK CONNECTICUT

APPROVED:

CHIEF, ENGINEERING DIV.

APPROVED:

LT. COL., C.E. ASST. TO DIVISION ENGINEER

DATE MAY 1956

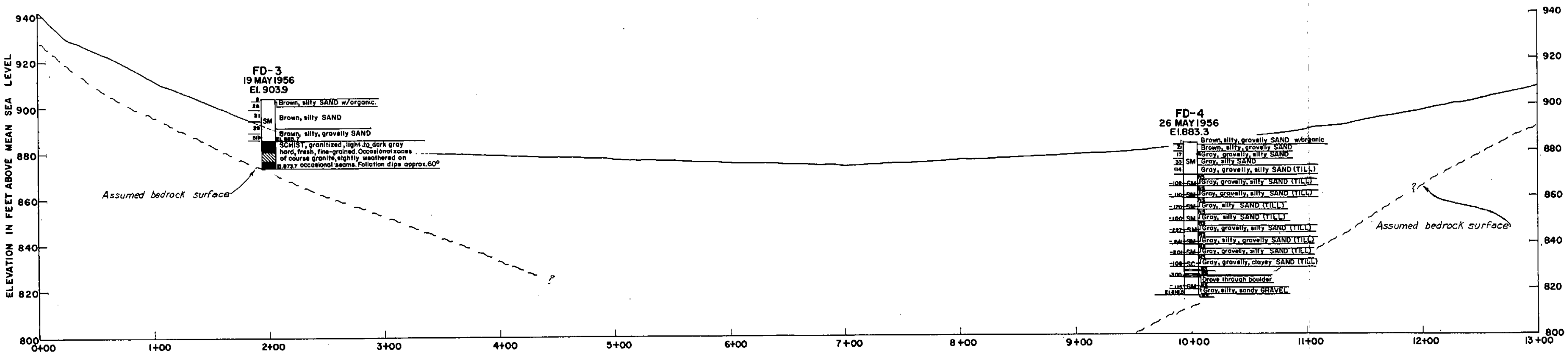
SCALE AS SHOWN

TO ACCOMPANY REPORT DATED 31 MAY 1956

DRAWING NUMBER HC-2-1000

SHEET 1 OF 2

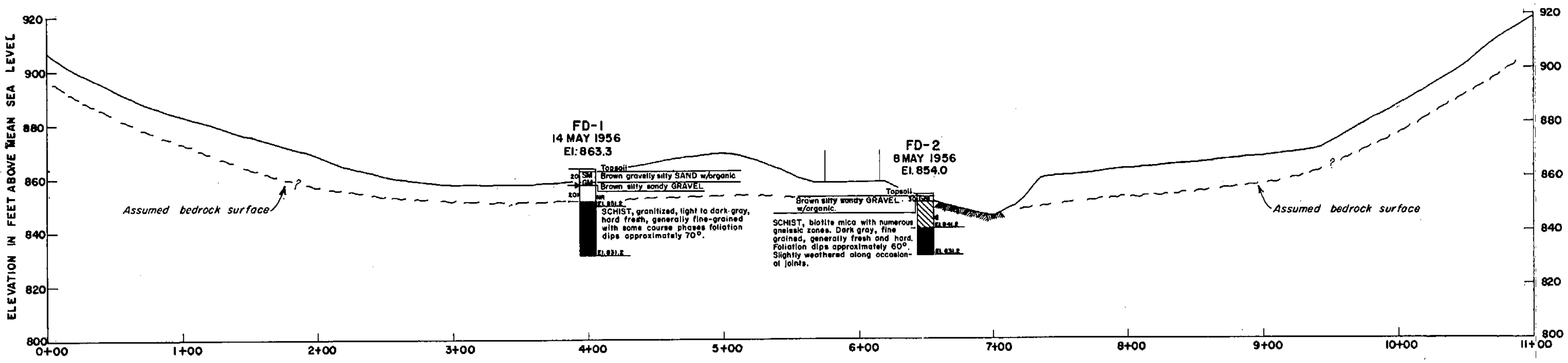
PLATE NO. A-1



GEOLOGIC-LOG SECTION B-B ℄ DIKE

(LOOKING UPSTREAM)

SCALE: HOR. 1" = 40'
VERT. 1" = 20'

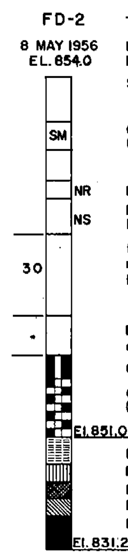


GEOLOGIC-LOG SECTION A-A ℄ DAM

(LOOKING UPSTREAM)

SCALE: HOR. 1" = 40'
VERT. 1" = 20'

LEGEND FOR GRAPHIC LOGS



- FD-2: Type and number of exploration.
- 8 MAY 1956 / EL. 854.0: Date exploration completed. Elevation of ground surface, at time of exploration.
- Subsurface water level in boring at time of exploration.
- SM: Group letter symbol according to Unified Soil Classification System
- NR: No Recovery or unsatisfactory soil samples recovered.
- NS: Not Sampled (Core-drilled, blasted, and/or washed-bored)
- 30: Blows per foot of penetration considered most representive for each sample drive using a 300 pound hammer with free fall of about 18 inches on
- Blow count not recorded or not considered representative.
- Cobble or boulder (Core-drilled).
- Cobble or boulders, continuous or nested. (Core-drilled and/or blasted and chopped.)
- El. 851.0: Elevation of bedrock surface.
- Rock core recovery 0-25%
- Rock core recovery 25-50%
- Rock core recovery 50-75%
- Rock core recovery 75-90%
- Rock core recovery 90-100%
- El. 831.2: Elevation at bottom of exploration.

NOTES:

For locations of explorations and geologic sections, see plan of explorations.

CORPS OF ENGINEERS, U. S. ARMY OFFICE OF THE DIVISION ENGINEER NEW ENGLAND DIVISION BOSTON, MASS.	
DR. BY R.F. / TR. BY R.F. / CK. BY HEB/RCO	HOUSATONIC RIVER FLOOD CONTROL
PROJECT ENGINEER	HALL MEADOW BROOK DAM GEOLOGY
SUBMITTED BY: CHIEF, PLANN. & RPT'S BRANCH	HALL MEADOW BROOK CONNECTICUT
APPROVED: CHIEF, ENGINEERING DIV.	APPROVED: LT. COL., C.E., ASS'T. TO DIVISION ENGINEER · DATE MAY 1956
TO ACCOMPANY REPORT DATED 31 MAY 1956	SCALE AS SHOWN DRAWING NUMBER HC-2-1001 SHEET 2 OF 2

LEGEND FOR GRAPHIC LOGS

FD-2 — Type and number of exploration.

11 MAY 1956 — Date exploration completed.
EL. 794.9 — Elevation of ground surface, at time of exploration.

Subsurface water level in boring at time of exploration.

SM — Group letter symbol according to Unified Soil Classification System.

NR — No Recovery or unsatisfactory soil samples recovered.

NS — Not Sampled (Core-drilled, blasted, and/or washed-bored).

48 — Blows per foot of penetration using a 300 pound hammer with free fall of about 18 inches on a 3" O.D. size sample spoon equipped with a bevelled and sharpened drive shoe.

Blow count not recorded or not considered representative.

Cobble or boulder (Core-drilled).

Cobble or boulders, continuous or nested. (Core-drilled and/or blasted and chopped.)

El. 784.6 Elevation of bedrock surface.

Rock core recovery 0-25%
Rock core recovery 25-50%
Rock core recovery 50-75%
Rock core recovery 75-90%
Rock core recovery 90-100%

El. 764.6 Elevation at bottom of exploration.

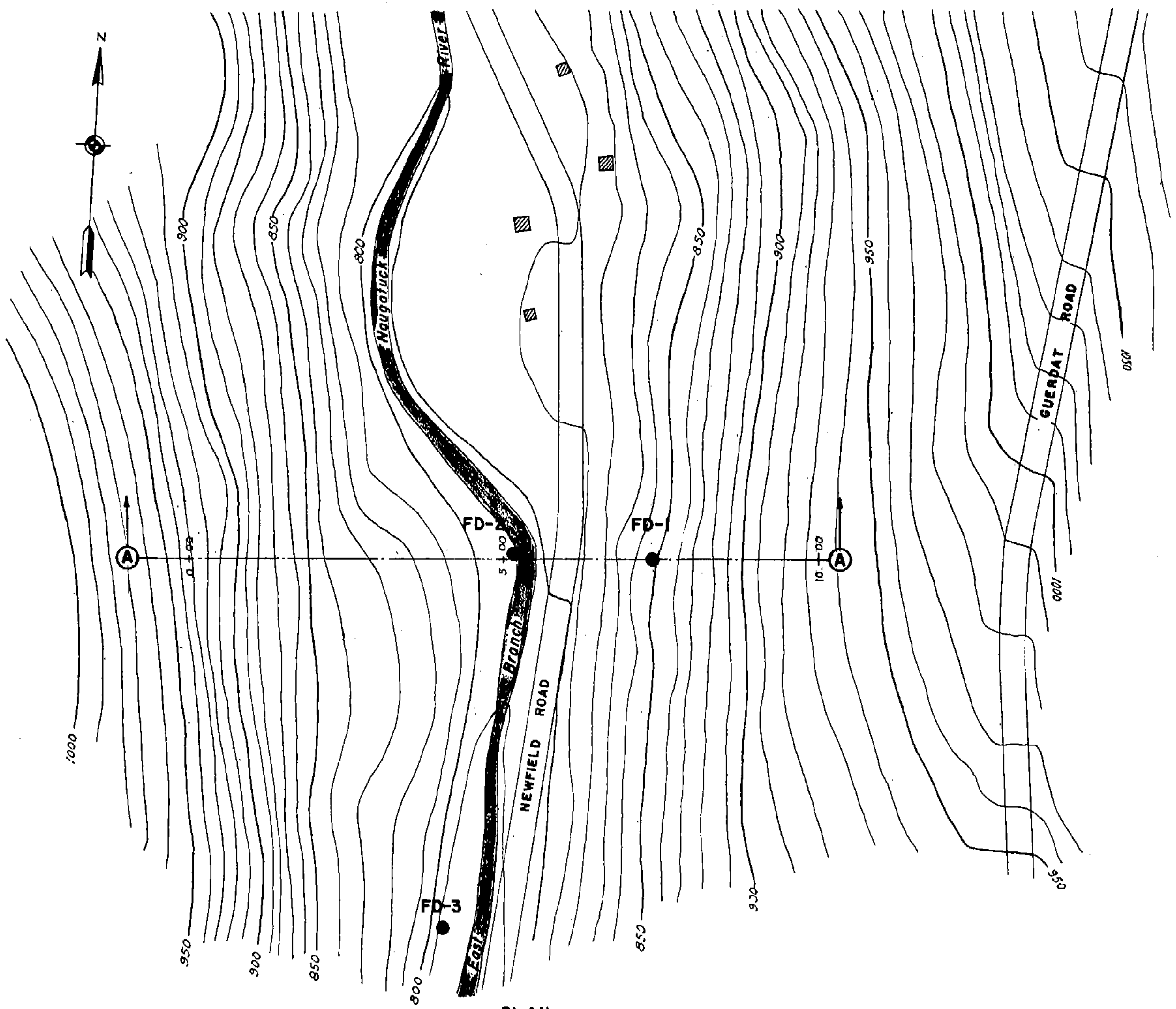
NOTES:

Elevations refer to Mean Sea Level Datum.

Contour interval is 10 feet.

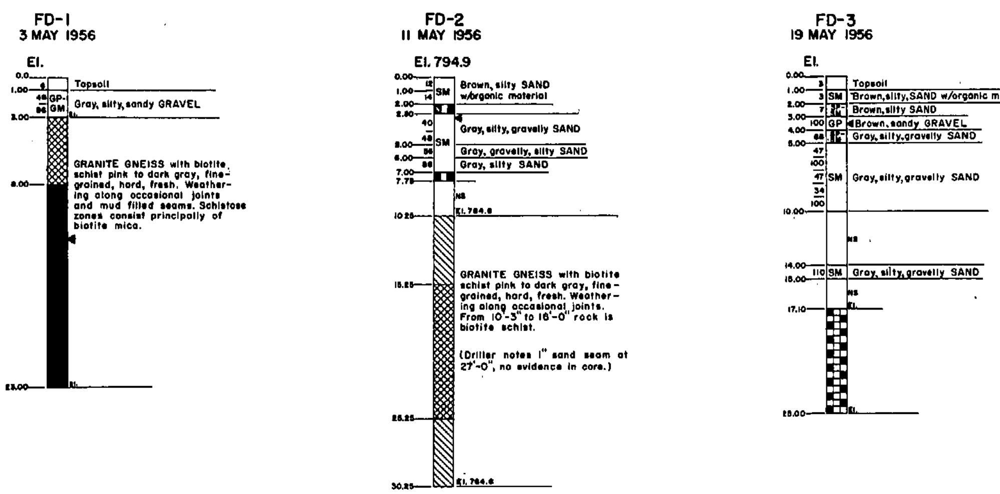
For Geologic-Log Section A-A, see Geology sheet.

Topography based on U.S. Geological Survey, Torrington Quadrangle, Connecticut.



PLAN

SCALE IN FEET
200' 0' 200' 400'



CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY	
L.B.	L.B.	HEB/RCG	HOUSATONIC RIVER FLOOD CONTROL

EAST BRANCH DAM

PLAN OF EXPLORATIONS

NAUGATUCK RIVER CONNECTICUT

PROJECT ENGINEER

SUBMITTED BY:
CHIEF, PLANN. & R'F'TS BRANCH

APPROVED:
CHIEF, ENGINEERING DIV.

APPROVED:
LT.COL., C.E. ASST. TO DIVISION ENGINEER

DATE MAY 1956

SCALE: AS SHOWN

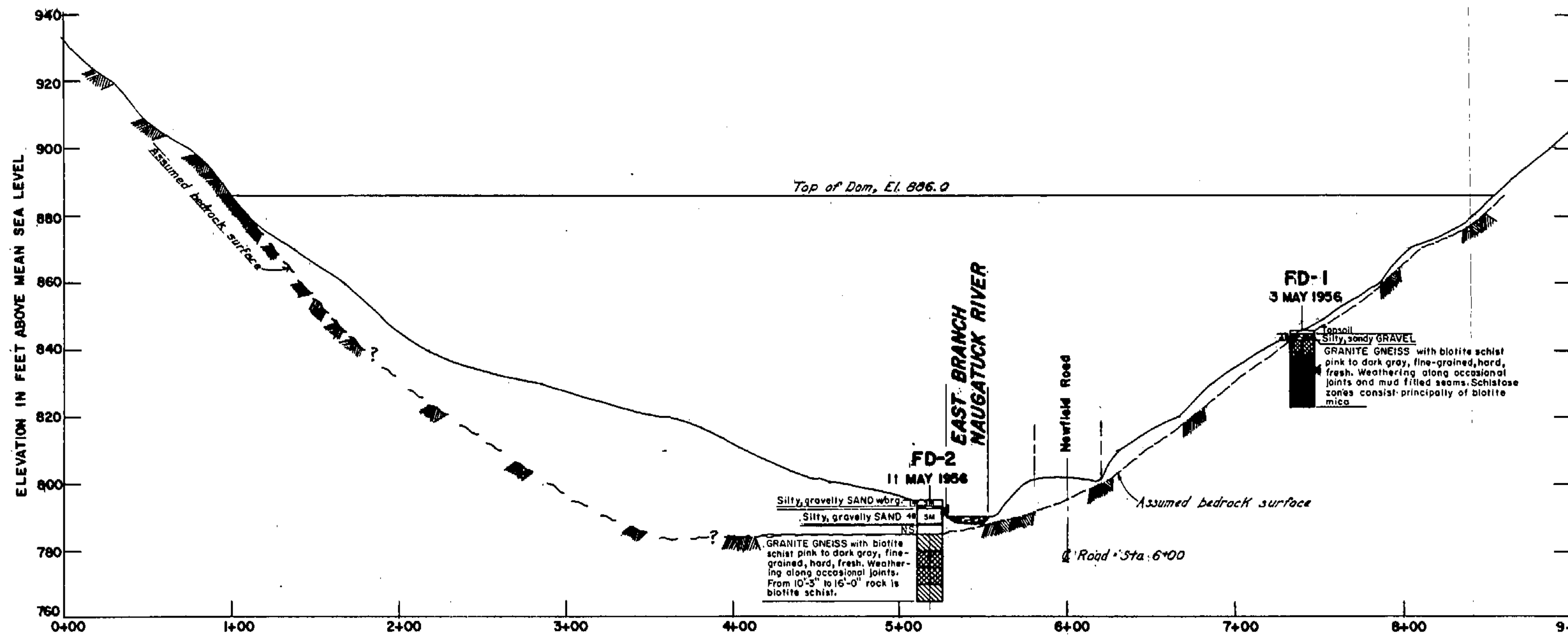
TO ACCOMPANY REPORT DATED 31 MAY 1956

DRAWING NUMBER HC-2-1002
SHEET 1 OF 2

CORPS OF ENGINEERS — U.S. ARMY

LEGEND FOR GRAPHIC LOGS

- **FD-2** — Type and number of exploration.
- **11 MAY 1956** — Date exploration completed.
- **EL. 794.9** — Elevation of ground surface, at time of exploration.
- Subsurface water level in boring at time of exploration.
- **SM** — Group letter symbol according to Unified Soil Classification System.
- **NR** — No Recovery or unsatisfactory soil samples recovered.
- **NS** — Not Sampled (Core-drilled, blasted, and/or washed-bored)
- **70** — Blows per foot of penetration considered most representive for each sample drive using a 300 pound hammer with free fall of about 18 inches on a 3" O.D. size sample spoon equipped with a bevelled and sharpened drive shoe.
- **•** — Blow count not recorded or not considered representative.
- Cobble or boulder (Core-drilled)
- Cobble or boulders, continuous or nested. (Core-drilled and/or blasted and chopped.)
- **El. 784.6** Elevation of bedrock surface.
- Rock core recovery 0-25%
- Rock core recovery 25-50%
- Rock core recovery 50-75%
- Rock core recovery 75-90%
- Rock core recovery 90-100%
- **El. 764.6** Elevation at bottom of exploration.



GEOLOGIC-LOG SECTION A-A ℄ DAM

(LOOKING UPSTREAM)

SCALE: HOR. 1" = 40'
VERT. 1" = 20'

NOTES

Elevations refer to Mean Sea Level Datum.

For record and location of all explorations and location of geologic section, see plan of explorations.

CORPS OF ENGINEERS, U. S. ARMY OFFICE OF THE DIVISION ENGINEER NEW ENGLAND DIVISION BOSTON, MASS.	
DR. BY LB — TR. BY LB — CK. BY HED/ECB	HOUSATONIC RIVER FLOOD CONTROL **EAST BRANCH DAM** **GEOLOGY**
PROJECT ENGINEER	
SUBMITTED BY: CHIEF, PLANN. & R'PTS BRANCH	NAUGATUCK RIVER — CONNECTICUT
APPROVED: CHIEF ENGINEERING DIV.	APPROVED: LT.COL. C.E. ASST. TO DIVISION ENGINEER — DATE MAY 1956
TO ACCOMPANY REPORT DATED 31 MAY 1956	SCALE: AS SHOWN DRAWING NUMBER HC-2-1003 SHEET 2 OF 2

APPENDIX B

FLOOD LOSSES AND BENEFITS

APPENDIX B

FLOOD LOSSES AND BENEFITS

APPENDIX B

FLOOD LOSSES AND BENEFITS

B1. SCOPE

The enormous losses caused by the flood of August 1955 throughout the Naugatuck River basin exceeded by far those experienced in the floods of 1938 and 1948, the previous major floods in the basin. Total losses experienced in the Naugatuck basin in August 1955 are estimated at $220,320,000. Damages experienced in 1938 and 1948 were estimated at $626,000 and $1,254,000, respectively, while a recurrence of the 1938 and 1948 conditions would cause losses estimated at $1,792,800 and $1,755,600, respectively, under current conditions.

A feature of the August 1955 flood as compared to previous floods was the abnormally high incidence of large-scale structural damage. Throughout the basin, buildings, bridges, sewer, water and gas lines, highways, and railroads were heavily damaged or completely destroyed. The October 1955 flood occasioned serious concern in the area, but actural damage was not great. Emergency rehabilitation work after the August disaster, advance warning, and limited operation of many facilities rendered operative by the previous flood, substantially reduced potential losses.

Brief descriptions of damage surveys, loss summaries, flood area, and derivation of annual losses and benefits are given in this Appendix. A distinction is made between (1) the reach extending from reservoir sites above Torrington to the upstream end of the authorized Thomaston project, and (2) the reach between the Thomaston dam site and the mouth of the Naugatuck River.

B2. DAMAGE SURVEYS

Damage-survey parties were sent to the flood area during, and immediately after, the flood. In view of the great increase in losses over previous floods, the information gathered was referenced to 1955 flood stages. Later correlation with data obtained subsequent to 1938 and 1948 high waters was made by an office review. Essentially, the survey was a door-to-door inspection and interview of the thousands of industrial, commercial, residential, and other properties affected by the flood. Information obtained included the extent of the area flooded, descriptions of properties, nature and amount of damage, depth of flooding, high-water references, and relationships to prior flood stages. Evaluations of damage reasonably consistent with evidence in the field were generally furnished by property owners. Where these estimates appeared unrealistic, they were modified by the investigators. If owners were unable to furnish loss estimates, the investigator made his own evaluation. Sampling methods were employed where several residences of similar characteristics and like depth of flooding were encountered. Valuable information was also obtained from local and State officials and from utility companies which experienced damage at several points in this and other river basins. Such central sources of information were extensively used to save time and keep costs at a minimum.

Sufficient data was obtained to derive losses for (1) 1955 stage, (2) a stage 3 feet in excess of 1955, (3) intermediate stages denoting sharp changes in stage-damage relationships, and (4) the stage where damage begins (zero damage) referenced to the 1955 flood level.

B3. LOSS CLASSIFICATION

Flood-loss information was recorded by type of loss and by location. The loss types used were: industrial, urban (commercial, residential, public), rural, highway, railroad, and utility. The type of loss was recorded by location within towns and by river reaches to provide a basis for later use in annual loss and benefit analyses. Damage reaches are described in Table B-I.

TABLE B-I

DAMAGE REACHES
NAUGATUCK RIVER, CONNECTICUT

Reach Number	Description of Reach
1	East Branch Dam Site to East Main Street Bridge
2	Hall Meadow Brook Dam Site (West Branch) to Center Bridge
3	East Main Street and Center Bridges to Thomaston Dam Site
4	Thomaston Dam Site to Spruce Brook (Waterbury town line)

TABLE B-1 (Cont.)

DAMAGE REACHES
NAUGATUCK RIVER, CONNECTICUT

Reach Number	Description of Reach
5	Spruce Brook to Mad River
6	Mad River to Hockanum Brook
7	Hockanum Brook to American Brass Company Dam (Seymour, Connecticut)
8	American Brass Company Dam to tidewater at Division Street (Ansonia-Derby town line)
9	Below Shelton Dam and Division Street Bridge (in tidewater)

Total losses include direct and associated losses. Direct losses comprise (1) physical losses such as damage to structures, machinery, and inventory and costs of clean-up and repairs; and (2) non-physical losses such as non-recovered loss of business, wages, and production; increased cost of operation; cost of temporary facilities; and increased cost of shipment of goods to persons and properties in the inundated area. Associated losses comprise increased cost of travel and shipment, loss of utilities and transportation, and loss of production and wages not later recovered by persons and properties in areas adjacent to the inundated areas. The direct loss resulting from physical damage and a large part of the related non-physical loss were determined by direct inspection of property and evaluation of losses by the property owner or field investigators from this office, or both. The non-physical portion of the direct loss was often difficult to estimate on the basis of information available at a given property. Where this condition existed, the relationship between physical and non-physical losses was based on the relationship found for similar properties in the area. Associated losses were determined by field analyses and evaluations, after consultation with the affected property owners and agencies, supplemented by the relationship of associated losses to total losses in New England river basins. In the Naugatuck Basin as a whole, the associated losses account for 9.3% of the total.

B4. LOSS SUMMARY

Total losses for the August 1955 flood have been summarized by type for towns and river reaches on Tables B-II and B-III.

TABLE B-II

AUGUST 1955 FLOOD LOSSES BY TOWNS

NAUGATUCK RIVER CONNECTICUT
(Loss in $1,000)

Town	Urban	Rural	Industrial	Utility	Highway	Railroad	Total
Torrington	10,040.	-	9,300.	1,200.	1,570.	300.	22,410.
Litchfield	240.	-	90.	-	530.	40.	900.
Harwinton	260.	20.	-	-	100.	-	380.
Thomaston	1,270.	-	11,190.	1,000.	1,390.	210.	15,060.
Watertown	290.	-	-	-	-	-	290.
Waterbury	25,000.	-	63,470.	1,020.	1,760.	3,560.	94,810.
Naugatuck	6,770.	-	24,890.	120.	1,900.	530.	34,210.
Beacon Falls	1,860.	-	3,920.	-	420.	530.	6,730.
Seymour	3,250.	-	3,910.	870.	1,240.	560.	9,830.
Ansonia	6,160.	-	20,450.	120.	1,780.	630.	29,140.
Derby	240.	-	4,050.	10.	160.	2,100.	6,560.
	55,380.	20.	141,270.	4,340.	10,850.	8,460.	220,320.

TABLE B-III

AUGUST 1955 FLOOD LOSSES BY REACHES

NAUGATUCK RIVER, CONNECTICUT
(Loss in $1,000)

Reach	Urban	Rural	Industrial	Utility	Highway	Railroad	Total
1	1,330.	-	790.	350.	70.	-	2,540.
2	3,760.	-	7,060.	350.	250.	260.	11,680.
3	5,470.	20.	1,530.	500.	2,370.	170.	10,060.
4	1,550	-	11,190.	1,010.	900.	110.	14,760.
5	20,660	-	58,530	460.	1,200.	3,320.	84,170.
6	11,560.	-	33,680.	670.	2,680.	1,190.	49,780.
7	4,650.	-	3,970.	870.	1,440.	680.	11,610.
8	6,160.	-	20,470.	120.	1,780.	630.	29,160.
9	240.	-	4,050.	10.	160.	2,100.	6,560.
Total	55,380	20.	141,270.	4,340.	10,850.	8,460.	220,320.

B5. ANNUAL LOSSES

Estimates of flood losses have been converted to annual losses to provide a basis for comparing annual benefits to annual costs. Annual loss figures presented herein have been derived in accordance with standard Corps of Engineers practice utilizing stage-damage, stage-discharge, and discharge-frequency relationships. Typical curves used in annual loss computations are shown on Plate B-1.

Stage-damage data for individula properties was summarized by reaches, which have relatively uniform hydraulic characteristics throughout. The stage-damage curve was combined with stage-discharge data to develop a discharge-damage curve. A discharge-frequency relationship was then used to obtain a curve for the damage-frequency relationship. This curve was plotted with damage as the ordinate and percent chance of occurrence (reciprocal of frequency) as the abscissa. The area under this curve is a measure of the annual loss.

Annual losses for the three reaches below the Hall Meadow Brook and East Branch Reservoirs and upstream of Thomaston Reservoir are summarized below:

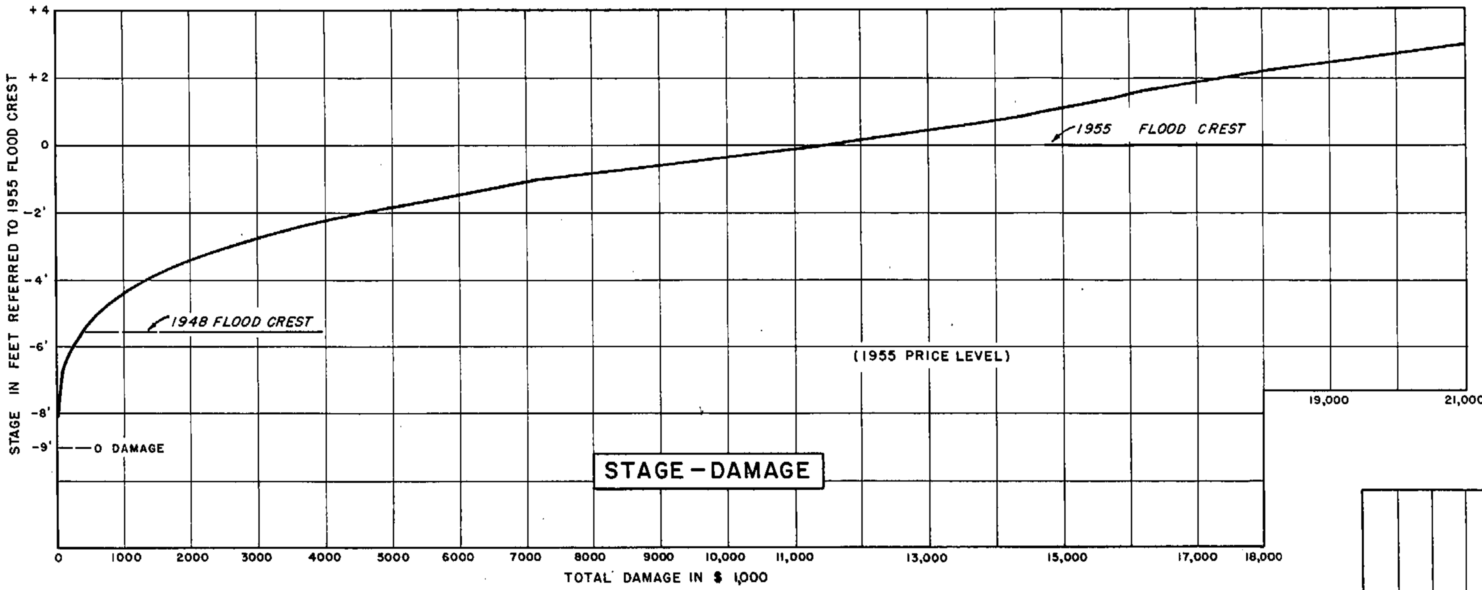
Reach	Annual Loss
1	$ 65,200
2	252,000
3	142,000

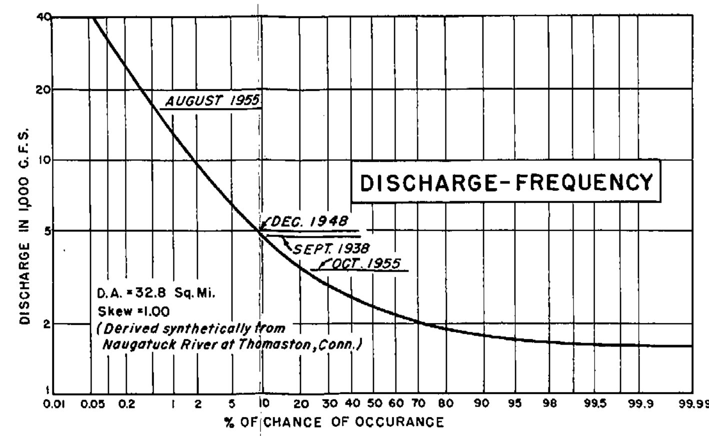
B6. ANNUAL BENEFITS

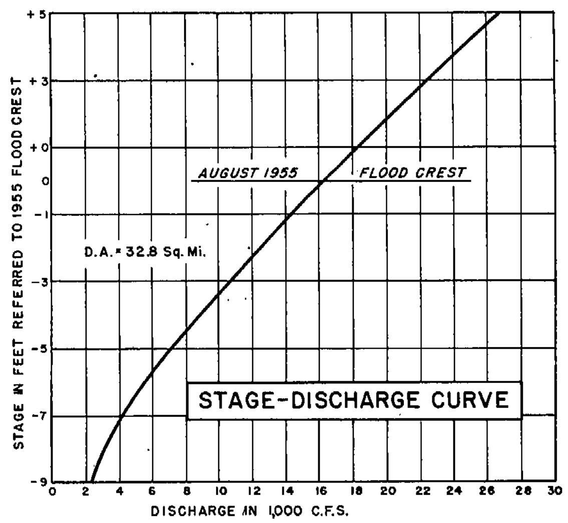
Annual benefits were derived for the reaches above Thomaston Reservoir by determining the difference between the annual losses under present conditions and those remaining after construction of the Hall Meadow Brook and East Branch projects. Concurrent with determination of annual losses under present conditions, losses were determined for a reduction in peak discharges of 10, 20, 40, and 60%. The reduction in losses resulting from the reduction in discharges represents the benefits accruing to flow reduction. In this manner a relationship is established between annual benefits and reduction in flows. Hydraulic and hydrologic analyses determine to what degree flows are modified by the project under consideration. On Hall Meadow Brook, all benefits are credited to flow reduction by Hall Meadow Brook project; on the East Branch, all benefits are credited to the East Branch project. Below the confluence of the two branches, the total benefits attributable to the combined reduction provided by the two projects are allocated between the projects in proportion to the reduction each project would obtain if acting alone. This procedure resulted in an allocation of 53% to Hall Meadow Brook and 47% to East Branch. The estimated benefits to Hall Meadow Brook and East Branch projects, respectively, in the reaches above Thomaston Reservoir, are $227,500 and $114,500.

In addition, downstream benefits were derived for the projects acting in support of the Thomaston project in the larger and more in-frequent floods. Hydrologic analysis indicates that for floods more frequent than once in 100 years, the capacity of Thomaston is sufficient.

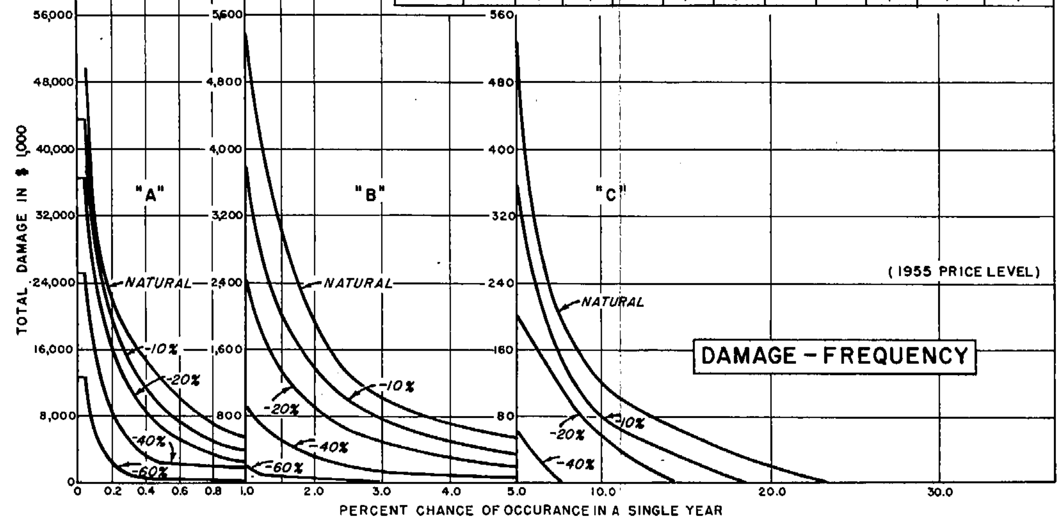
Consideration was given to the 8-inch storage capacity of Thomaston in computing the effect of upstream reservoirs. The upstream reservoirs have a drainage area of 21.5 square miles, and 8 inches of storage would comprise 9,150 acre-feet. At Thomaston this upstream storage would be equivalent to about 8,000 acre-feet. Inasmuch as the storage capacity at Thomaston is 41,500 acre-feet, the upstream storage would increase the available storage by about 19%. It is estimated that the increase in storage would reduce flow in the larger floods by about 15%. Such reduction in flow would increase the benefits below Thomaston to be realized from large floods by 6%. Present estimates indicate that annual benefits for Thomaston Reservoir in the larger floods amount to $500,000. Benefits assignable to upstream reservoirs thus are about $30,000, of which $16,500 is attributable to Hall Meadow Brook and $13,500 to East Branch. Total annual benefits are estimated at $244,000 for Hall Meadow Brook and $128,000 for East Branch.

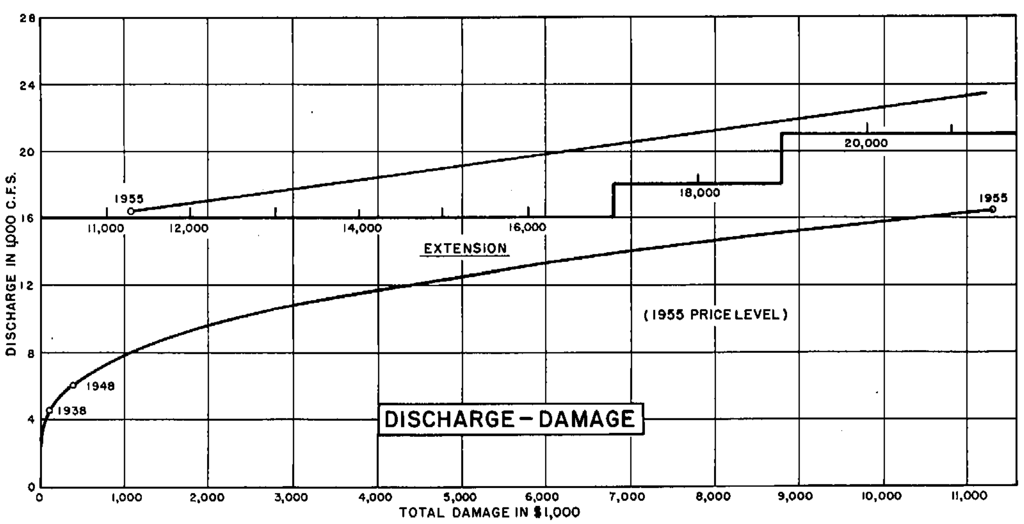


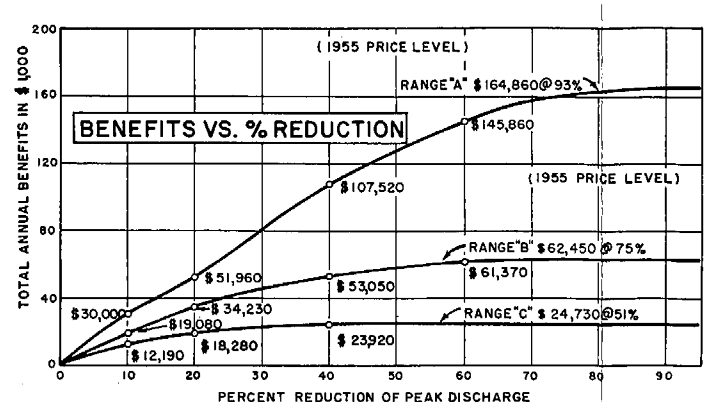




	RANGE "A" 1 □" = $ 32,000			RANGE "B" 1 □" = $ 8,000			RANGE "C" 1 □" = $ 32,000			TOTAL	
	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	AREA □"	ANNUAL LOSS	ANNUAL BENEFIT	ANNUAL LOSS	ANNUAL BENEFIT
NATURAL	5.15	$164,860		7.81	$62,450		7.73	$24,730		$ 252,040	
– 10%	4.20	$134,760	$30,100	5.42	$43,370	$19,080	3.92	$12,540	$12,190	$ 190,670	$61,370
– 20%	3.50	$112,900	$51,960	3.53	$28,220	$34,230	2.02	$6,450	$18,280	$ 147,570	$104,470
– 40%	1.79	$57,340	$107,520	1.18	$ 9,400	$53,050	0.25	$ 810	$23,920	$67,550	$184,490
– 60%	0.59	$19,000	$145,860	0.14	$ 1,080	$61,370	0	0	$24,730	$20,080	$231,960







HOUSATONIC RIVER BASIN
NAUGATUCK RIVER WATERSHED

DATA FOR ECONOMIC ANALYSIS OF DAMAGE ZONE 14 b

CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS.

APPENDIX C

LETTERS OF CONCURRENCE AND COMMENT

APPENDIX C

LETTERS OF CONCURRENCE AND COMMENT

Exhibit No.	Source
1	Naugatuck Valley River Control Commission
2	City of Torrington Flood and Erosion Control Board
3	Fish and Wildlife Service, Department of Interior
4	Federal Power Commission
5	State of Connecticut Flood Control and Water Policy Commission
6	City of Torrington
7	Connecticut State Highway Department

STATE OF CONNECTICUT

THE NAUGATUCK VALLEY RIVER CONTROL COMMISSION

ONE CENTRAL AVENUE
WATERBURY, CONNECTICUT

PLAZA 5-0175

May 14, 1956

Brig. General Robert J. Fleming, Jr., Division Engineer
Corps of Engineers, U.S. Army
150 Causeway Street
Boston, Mass.

Dear General Fleming:

This Commission which is charged by statute with the correlation of efforts of Federal and State agencies in connection with flood control on the Naugatuck River and its tributaries, approves wholeheartedly the proposals which you have made in connection with the establishment of reservoirs on the west branch (Hall Meadow) and the east branch (East Branch) of the Naugatuck River at Torrington.

Approval of these reservoirs is based upon a detailed study of the proposals made by the Engineering Advisory Group of the Commission. We earnestly urge the early authorization and construction of these projects.

It is the feeling of this Commission which has full knowledge of the financial status of the state and the municipalities, that the cost of these projects should be borne by the Federal Government.

Yours very truly,

C L Eyanson

Chairman

C.L. Eyanson/ac

EXHIBIT 1

CITY OF TORRINGTON

FLOOD AND EROSION CONTROL BOARD

Torrington, Connecticut

Rooms 313-314
City Hall

Telephone:
HUnter 9-8028

May 10, 1956

800.5 (Torrington Conn.)-12

Brig. General Robert J. Fleming, Jr.
Corps of Engineers, U. S. Army
Office of the Division Engineer
New England Division
150 Causeway Street
Boston 14, Mass.

Dear General Fleming: Re: Dry Dams Above Torrington

As Chairman of the Torrington Flood and Erosion Control Board, I wish to express the appreciation of the members of the Board and its Sub-Committee, on behalf of the splendid cooperation we have received from you and your excellent personnel on our flood problems.

The local Flood Board members have studied the facts and figures and reviewed the plans for the proposed dry dams above Torrington. This Board wishes to express the firm belief that the construction of both the Hall Meadow and East Branch dry reservoirs are of the greatest importance to Torrington in the permanent flood control plans. There is complete concurrence on the part of this local Flood Board on plans which you have submitted, and it believes that every possible step should be taken to expedite submission in order to have these two projects included in a separate section of the Omnibus Bill in Congress at the earliest possible date. This is an urgent request that the work be carried out with the greatest possible speed.

In view of the fact that approximately $600,000.00 have been spent to date by the City of Torrington, and a further sum of $200,000.00 is contemplated, for acquisition of land for flood control measures, it is the opinion of this Board that this investment must be protected. It is hardly within the power of the City of Torrington to finance any part of the project of construction of these dams.

The State of Connecticut Highway Department is designing a replacement for the Main Street center bridge. Present planning necessitates flood control above Torrington to reduce flood waters which must flow under this bridge in the West Branch of the Naugatuck River. Figures used in this design have been computed anticipating construction of the Hall Meadow reservoir, thus reducing the flow by the necessary cubic feet per second during high water periods for flood control purposes.

EXHIBIT 2

(Gen. Fleming 5/10/56cont'd)

It is virtually impossible to increase the height of this bridge without unreasonable and economically impractical damage to adjacent buildings and street levels on both sides of this bridge.

This Board stands ready to carry out any request and comply with any suggestions which you may make in connection with speeding Congressional approval for the protection of life and property in the City of Torrington.

Very truly yours,

Chester W. Moore
ML

Chester W. Moore
Chairman
Torrington Flood and Erosion
Control Board

ML

REGION 5

NEW ENGLAND STATES
NEW YORK
PENNSYLVANIA
NEW JERSEY
DELAWARE
WEST VIRGINIA

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

OFFICE OF REGIONAL DIRECTOR
BLAKE BUILDING
BOSTON 11, MASSACHUSETTS

May 14, 1956

800.5 (Naugatuck Conn.)

Division Engineer
New England Division
U. S. Corps of Engineers
150 Causeway Street
Boston 14, Massachusetts

Dear Sir:

Reference is made to your letter of May 4, 1956 in which you requested comments from this office in relation to three potential reservoirs in Connecticut. The three reservoirs under consideration are East Branch Nangatuck, Hall Meadow Brook and Mad River.

The information concerning these reservoirs in the attachment is of a preliminary nature and is based on a cursory field examination of the proposed reservoir sites. The information is not regarded as adequate to fulfill our obligations under the Coordination Act (60 Stat. 1080).

This office welcomes the opportunity to comment on these projects during preliminary stages of planning. Detailed reports will be prepared when required by your office.

Very truly yours,

E. W. Bailey
E. W. Bailey
Acting Regional Director

Attachment

EXHIBIT 3

Preliminary Statement of Relation of Fish and Wildlife Resources to Proposed Reservoir Developments at East Branch Naugatuck, Hall Meadow Brook and Mad River, all in Connecticut

East Branch Naugatuck

This small reservoir site of 180 acres to be located on the East Branch Naugatuck River near Torrington, Connecticut contains fish and wildlife resources of largely local importance. Because of the small size of the area, as well as the pattern of land use, wildlife resources are of only nominal importance. Ruffed grouse and cottontail rabbits comprise the wildlife species of chief value on the site. It is not anticipated that wildlife values will be decreased in the post-development period provided lands and easements are made available to the public for hunting purposes.

The East Branch Naugatuck River is an important trout stream locally, and attracts fair numbers of anglers, especially from Torrington. A segment of the stream in the reservoir vicinity is reserved for juvenile fishermen exclusively. The stream is of good quality and is stocked with trout annually. Trout are also naturally produced in the area. Damages from relatively infrequent and short-term flooding should not be severe. It is important that the stream be made available to the public for fishing purposes in the post-development period. A most important feature which would be valuable from the fishing standpoint, as well as esthetically, would be the retention of woody vegetation, including shade trees along the stream course. This feature is urged, if it is at all feasible.

Hall Meadow Brook

This site is considerably larger than the East Branch location, and contains a smaller acreage devoted to various cultural features such as homesites. Wildlife values are correspondingly greater. As in the case of the East Branch project, stipulations granting free access for hunting on project lands and easements should compensate for the undesirable impact of flooding.

Hall Meadow Brook is also a locally important trout stream that is regularly stocked. Although certain damages are anticipated from flooding, it is believed that these can be partially compensated by retaining woody cover and shade trees along the stream course.

Mad River

This project would be situated on the Mad River just upstream from Winsted, Connecticut. Wildlife values are nominal on this semi-developed area. As in the case of the East Branch project, considerable of the 180 acres are devoted to homesites. Wildlife losses would be minor and would compare to the minor losses expected at East Branch. Free access for hunting should also be provided at this project in the post-development period.

The Mad River also is a trout stream that is stocked annually by the State of Connecticut. It is an attractive stream, but is badly scoured as a result of flooding. Although some damages would accrue as a result of flooding in the post-development period, these damages could be considerably reduced if woody cover were left standing along the stream in the reservoir area.

FEDERAL POWER COMMISSION

REGIONAL OFFICE

139 CENTRE STREET, NEW YORK 13, N.Y.

May 16, 1956

800.5 (N.E.D.)

The Division Engineer
New England Division
Corps of Engineers
150 Causeway Street
Boston 14, Massachusetts

Dear Sir:

Reference is made to your letter of May 4, 1956 inclosing data on three potential dam and reservoir projects currently being studied by your staff in connection with the New England flood control program and requesting our comments thereon.

Two of the projects, East Branch, Naugatuck River and Hall Meadows Brook, are located in the Housatonic River basin and one, Mad River Reservoir, on the Farmington River, a tributary of the Connecticut River basin.

It is understood that these reservoirs will be operated for flood control only and no permanent pool for recreation or other purposes is planned at this time. Pertinent data on the projects as shown in the referenced letter are summarized in the following:

Project	East Branch Naugatuck River	Hall Meadows Brook	Mad River Reservoir
River Basin	Housatonic	Housatonic	Connecticut
Drainage Area, sq.mi.	9.25	12.2	18.15
Capacity, Ac.Ft.	5,150	7,200	9,630
Reservoir Area, Acres	180	350	180
Top Elevation Dam, m.s.l.	886	905	988
Elevation SpillwayCrest,msl	871	890	973
Maximum Height dam, feet	95	55	168

In view of the small drainage area controlled by the projects and the need to preempt available storage capacity for flood control only, this office concludes that the development of hydroelectric power or conservation storage at these projects would not be economically feasible.

Very truly yours,

D J Wait

D. J. Wait
Regional Engineer

EXHIBIT 4

STATE OF CONNECTICUT

FLOOD CONTROL AND WATER POLICY COMMISSION

STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

May 15, 1956

Corps of Engineers, U. S. Army
New England Division
150 Causeway Street
Boston, Massachusetts

Attention: Mr. H. J. Kropper, Chief - Engineering Division

Dear Mr. Kropper:

Reference is made to your letters of 19th April and 2nd May, requesting comments on a proposed system of flood control dams in the Naugatuck River basin and one in the Farmington River above Winsted. This office is vitally interested in a proposal of this type which calls for the construction of storage reservoirs on small drainage basins. In our studies of these matters in 1948 and 1949, we tabulated all the drainage basins in Connecticut which were larger than 25 square miles and which did not have a railroad running along the valley bottom. Within the State there are only 25 such basins. We may assume that if such a basin does not control more than 10% of the area above a population center of 5,000, it probably has little value for flood control. Such a criteria eliminates 15 of these 25 areas as possible locations for flood control structures. One of these is too large for a practical structure; four of them are already controlled and another will be. Of the remaining four, two are relatively unimportant, and the other two happen to be the Naugatuck River above Torrington and Mad River above Waterbury. We, therefore, concluded at that time and we are more convinced at present that if Connecticut is to obtain further flood control by storage reservoirs after the Thomaston Dam is completed, such control must be constructed in the small drainage basins you are considering.

Therefore, the overall plan as outlined in the material presented to this office conforms with our general thinking on flood control for the Naugatuck River. The area above Torrington is divided into two basins which can be protected by dams constructed at three particular sites. The major part of the area (about two-thirds) is on the West Branch of the Naugatuck River. The smaller tributary, the East Branch, is provided some flood amelioration by Lake Winchester and Park Pond. The dam proposed would be of considerable benefit to property along the East Branch in Torrington and is a reasonable structure. There are, however, over 40 domiciles affected. These structures are average family homes. The values along the relatively short stretch of the East Branch in Torrington would have to be weighed against this dislocation within the reservoir area. It is noted that structures along the lower section of the East Branch are also subject to flooding from the West Branch and that the upper reach of the East Branch in Torrington is fed from a considerably smaller drainage area than the East Branch at its mouth. On the West Branch the Hall Meadow site is ideal from several aspects. The capacity of this relatively low dam structure will be sufficient to completely eliminate contributing water from this area during time of flood. A relatively few domiciles will be affected. It has appeared to some interests that the construction of a dam at or near Still Water Pond would provide greater protection

EXHIBIT 5

at Torrington because a greater drainage area exists at this point. The construction of a dam at this location would be more difficult. At the present state of our investigation we believe that a practical site would be in the middle of Still Water reservoir. The amount of property necessary over and above that which could be obtained easily from the owners of Still Water reservoir is about the same as would be required for Hall Meadow reservoir. The capacity in inches of runoff of a possible reservoir at this point would not be as great as Hall Meadow. The additional area which would be controlled over and above Hall Meadow Brook is at present subject to some flood amelioration by the existence of North Pond, Ruebon Hart Reservoir, Still Water Pond itself and other small ponds. We concluded, therefore, that it is most practicable to construct a flood control reservoir at the Hall Meadow site. Because this most practical site on the West Branch controls a small percentage of the total area above Torrington, the East Branch site achieves an even more desirable flood control value and demands an even more minute comparison of the benefits and damages.

****

The preceding is an excerpt from a letter to Mr. H.J. Kropper, Chief, Engineering Division, New England Division, Corps of Engineers, U.S. Army, from Mr. John J. Curry, Chief Engineer, State of Connecticut, Flood Control and Water Policy Commission.

CITY OF TORRINGTON

Office Of
WILLIAM T. CARROLL
Mayor
City Hall Building

Torrington, Conn.

800.5 (Torrington Conn.)-15

May 16, 1956

Brig. General Robert J. Fleming, Jr.
Division Engineer
New England Division
Corps of Engineers, U.S. Army
150 Causeway Street
Boston 14, Mass.

Dear General Fleming:

The City of Torrington, Connecticut has studied the proposals to construct the Hall Meadow and East Branch Flood Control Reservoirs on the West and East Branches of the Naugatuck River upstream from Torrington. These proposals were discussed in a meeting on May 9, 1956, in Torrington with representatives of the following agencies:

Conn. Flood Control and Water Policy Commission

Naugatuck River Valley Flood Control Commission

The Torrington Flood and Erosion Control Board

Representatives of the Corps of Engineers

The proposals to construct these reservoirs are fully concurred in all respects by the City of Torrington and all agencies concerned are requested to expedite any actions necessary to further their construction.

As you know, the City of Torrington has committed itself to expend $800,000 for flood control improvements since the August 1955 flood and we are extremely anxious to see that flood control is provided Torrington and the Naugatuck River Valley.

Sincerely yours,

CITY OF TORRINGTON

William T. Carroll
Mayor

EXHIBIT 6

The following are excerpts from letters to the
New England Division, Corps of Engineers,
U. S. Army, from Ernest T. Perkins, Assistant
Chief Engineer, Connecticut State Highway Department

* *

May 4, 1956

In response to your letter of April 19, 1956, we offer the following comments relative to the effects of the proposed reservoir construction on present or future state highways. Our comments cover only those reservoir projects colored blue or yellow on your index map as you indicate these are the most feasible from an economic standpoint.

Construction of these reservoirs will be of advantage, of course, to the Department in all of its flood replacement bridge projects and contemplated highway improvements in the Naugatuck Valley in that, presumably, the waterway requirements for bridges and the anticipated flood levels will be lowered.

<u>Hall Meadow Brook Reservoir</u>

This will necessitate relocation of a portion of Conn. 72. As a result of the August 1955 flood, the bridge carrying this route over Hall Meadow Brook was destroyed and it was planned to advertise on April 23rd for bids on a replacement structure.

However, this project has been suspended until the results of Congressional action on the Connecticut Flood Control Program are known. A temporary structure, now in place over Hall Meadow Brook, will have to be maintained, if the dam is constructed, until a relocated Conn. 72 is completed. A decision not to build this dam will reactivate the bridge replacement project.

The reconstruction of Center Bridge, Torrington, on Conn. 8, where ample vertical clearance is now difficult to attain, will be greatly aided through a lessening of the waterway area requirement.

EXHIBIT 7

East Branch Naugatuck River Reservoir

No existing state highways will be affected by this project. It appears that it, too, will be of value as regards Center Bridge, Torrington.

* * * * * * * * * * * * * * * *

May 16, 1956

... I am also forwarding you additional comments on the Hall Meadow Brook reservoir in Torrington. I am forwarding the cost of the State highway relocations which we feel reflect the cost of 'replacing in kind' the present State highways affected by these two* flood control reservoirs. It is my understanding that such figures will be included in your report to Washington and that if approved would be the amounts turned over to the Highway Department in connection with the State highway relocations.

* * *

Hall Meadow Reservoir

The relocation of Route 72 appears generally satisfactory to the State. We have estimated the cost of the relocation in kind of Route 72 along this line as $400, 000 (see attached breakdown of costs). This figure also includes construction, rights-of-way, and engineering costs and would be acceptable to the State as a 'replacement in kind.' ...

* This letter deals with a dam under consideration on the Mad River above Winsted as well as the proposed dams on the Naugatuck. Only that portion relating to the dams on the Naugatuck is quoted here.

I would like, in closing, to reaffirm the opinion of the Highway Department with respect to these two projects and also with respect to the proposed dam on the east branch of the Naugatuck where there is no State highway relocation involved. These three flood control reservoirs would appear to be of considerable benefit to the citizens of this State and will greatly benefit certain State highway projects. The proposed reduction in the flood flow of the west branch of the Naugatuck River at Main Street in Torrington where the State is planning to reconstruct the bridge on Route 8 and where the flood flow of 17,000 cfs is estimated to be reduced to 11,000 cfs is highly significant...

APPENDIX D

HYDROLOGY

APPENDIX D

HYDROLOGY

APPENDIX D

HYDROLOGY

D1. CLIMATOLOGY

D1.1 Temperature. - The average annual temperature in the Naugatuck River watershed is about 47°F., ranging from about 50°F. near the coast to about 44°F. in the headwaters. Average monthly temperatures vary widely throughout the year. The minimum temperature recorded in the basin was -25°F.; the maximum recorded was 105°F. Freezing temperatures can be expected from the middle of November until the end of March. The records of temperature at Norfolk and Waterbury, Connecticut are summarized in Table D - I.

TABLE D - I

MEAN MONTHLY TEMPERATURES
(Degrees Fahrenheit)

	Norfolk 8 Years of Record			Waterbury 63 Years of Record		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	23.3	29.3	14.0	28.1	36.8	17.6
February	23.8	28.3	17.8	28.3	38.1	17.3
March	30.2	32.3	24.3	37.3	48.4	25.2
April	44.0	46.1	40.3	48.3	60.1	35.5
May	54.2	58.6	50.9	59.4	71.6	46.4
June	62.9	66.6	60.8	68.1	79.6	55.4
July	68.5	72.2	65.7	73.0	84.7	60.3
August	66.2	69.4	63.1	70.8	82.1	58.5
September	57.9	59.8	55.1	64.1	76.2	51.6
October	49.0	52.8	42.2	53.5	66.3	39.5
November	37.1	42.2	32.1	42.3	51.8	31.4
December	26.1	31.4	18.7	31.2	39.0	22.3
Annual	45.2	47.2	44.0	50.4	61.1	38.4

D1.2 <u>Precipitation</u>. - The mean annual precipitation over the Naugatuck River watershed is approximately 50 inches, uniformly distributed throughout the year. The maximum and minimum annual precipitation at Waterbury for 67 years through 1954 is 66.58 inches in 1901 and 31.21 inches in 1931. Waterbury records for 1955 are not available for the period August through December, but annual precipitation has been estimated at approximately 65 inches. At Norfolk at the upper limits of the watershed, the total precipitation for 1955 was 76 inches with 23.67 inches and 17.49 inches observed during August and October, respectively. Table D - II is a summary of monthly precipitation data.

TABLE D - II

MONTHLY PRECIPITATION RECORD
(In Inches)

	Norfolk 11 Years of Record			Waterbury 67 Years of Record		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	4.47	8.32	0.93	3.87	10.06	0.84
February	3.96	5.72	2.44	3.52	10.00	0.43
March	4.75	10.37	1.82	4.08	9.46	0.17
April	4.90	7.19	2.88	3.72	11.51	0.66
May	4.90	8.14	1.72	3.95	8.08	0.13
June	4.39	8.58	1.11	3.59	11.25	0.54
July	3.93	9.33	1.67	4.34	18.10	1.36
August	5.34	23.67	0.65	4.30	9.48	0.90
September	4.34	9.25	0.92	3.66	12.90	0.29
October	4.21	17.49	1.86	3.46	8.83	0.20
November	5.45	10.03	1.51	3.81	8.74	0.78
December	5.00	9.40	1.20	3.90	9.82	0.82
Annual	55.66	76.00	39.68	46.20	66.58	31.21

D1.3 Snowfall. - The annual snowfall over the watershed varies from about 35 inches near the coast to over 80 inches in the headwaters region. The average snowfall for 37 years of record at Norfolk is 80.3 inches. The water content of the snow cover in the early spring often totals 4 to 6 inches.

D2. HISTORY OF FLOODS

D2.1 Historic Floods. - The earliest recorded flood of significance in the Naugatuck River basin occurred in February 1691. Other significant floods were recorded in November 1853 and April 1954; these two were of about the same magnitude. The flood of October 1869 was the greatest prior to 1900 with other serious floods in January 1874 and January 1891. Since 1900 there have been many floods with the major ones in November 1927, March 1936, September 1938, December 1948, and August and October 1955.

D2.2 Streamflow Data. - The U.S. Geological Survey has published records of river stages and streamflow at three locations in the basin for various periods of time since 1918. The records are good to excellent, except during periods of ice when they are fair. Following major floods, additional peak-discharge data has been computed by the U.S. Geological Survey for many locations on the smaller tributaries. Flow data at the gaging stations is summarized in Table D - III.

TABLE D - III

STREAMFLOW RECORDS
NAUGATUCK RIVER WATERSHED

Location of Gaging Station	Drainage Area sq.mi.	Period of Record	Discharge (c.f.s.) Mean(1)	Maximum(2)	Minimum
Naugatuck River near Thomaston	71.9	1930-1955	139	41,600	7
Leadmine Brook near Thomaston	24	1930-1955	46.7	10,400	0.08
Naugatuck River near Naugatuck	246	1928-1955	457	106,000	24

(1) Includes 1952 water year
(2) Instantaneous discharge, August 1955

D2.3 Major Floods. - The Naugatuck River basin has experienced six major floods in the past 30 years. Peak discharges of these floods at the U.S. Geological Survey gaging stations near Thomaston and Naugatuck are tabulated in Table D - IV.

TABLE D - IV

MAJOR FLOODS - NAUGATUCK RIVER

Drainage Area (sq.mi.)	Thomaston 71.9	Naugatuck 246
Flood	Peak Discharge (c.f.s.)	Peak Discharge (c.f.s.)
November 1927	10,000 (est.)	26,000
March 1936	6,590	23,340
September 1938	9,970	25,300
December 1948	10,200	28,500
August 1955	41,600	106,000
October 1955	8,800	35,000

Following the August 1955 flood the U.S. Geological Survey determined the discharge by the slope-area method at the following locations:

	Drainage Area (c.f.s.)	Peak Discharge (c.f.s.)
West Branch Naugatuck near West Torrington	24.2	11,900
East Branch Naugatuck at Torrington	10.2	6,210

The November 1927 flood resulted from a rainfall of 5.5 inches that fell on 3-4 November on ground already saturated by excessive rains during the previous month. The flood of March 1936 was caused by four distinct storm centers that passed over the northeastern states between 9 and 22 March. The runoff from these rains was augmented by considerable snowmelt. The September 1938 flood resulted from the heavy rainfall that accompanied the tropical hurricane which passed over New England on 21 September. This rain fell on ground saturated by rains earlier in the month. The average rainfall over the Naugatuck River basin during this storm exceeded 10 inches. The flood of December 1948 resulted from about 9 inches of rain on frozen ground and was augmented by some snowmelt. The flood of August 1955 was caused by rainfall that preceded and accompanied hurricane "Diane." This rainfall, which averaged more than 13 inches in the upper watershed and 10 inches in the lower part of the basin, followed more than 7 inches of rain the week previous during hurricane "Connie." The flood of October 1955 resulted from a storm that moved up the Atlantic Coast from Florida and deposited 10 to 14 inches of rainfall over the upper half of the Naugatuck River Basin.

D2.4 Flood Profiles. - High-water profiles were determined from field data obtained after the floods of March 1936, September 1938, December 1948, and August 1955. Plate 2 (in the main report) shows these high-water profiles for the Naugatuck River basin above Thomaston.

D2.5 Flood Frequencies. - The frequency or per-cent chance of occurrence of peak discharges was determined from records of the three gaging stations in the watershed. The frequency analyses were made in accordance with procedures described in Civil Works Engineer Bulletins 51-1 and 51-14. Application to New England rivers is summarized in F.C.S. Memorandum No. 52-General-3, "Flood Frequency Studies in New England," which was distributed with Civil Works Bulletin 53-5 (2 April 1953). The method assumes that the logarithmic values of annual peak flows are normally distributed. This allows the discharge-frequency curve to be defined by its mean value and standard deviations as in a standard statistical analysis. A current review which includes the 1955 floods indicates that a skew factor of 1.0 is more realistic than the factor of 0.3 used previously. The natural discharge frequency curves for three locations in Torrington are shown on Plate D-1. These curves were determined from statistics derived for the Naugatuck River gaging station near Thomaston.

D3. ANALYSIS OF FLOOD FLOWS

D3.1 Scope and Purpose. - For purposes of this report, the analysis of the flood flows was limited to the area above Thomaston. The discharge data available was limited to the U.S. Geological Survey gaging stations near Thomaston and isolated peak-discharge data for the smaller tributaries.

The three highest floods of record (August 1955, December 1948, and September 1938) and the minor flood of June 1952 were analyzed to determine the flood-producing potentialities of the upper Naugatuck River.

D3.2 Analysis. - For purpose of hydraulic analyses, the area above Thomaston was divided into three components or river reaches, the East Branch, the West Branch and the Naugatuck between Torrington and Thomaston. Hydrographs were developed for the ungaged areas by analyzing the rainfall distribution, snow-cover pattern, and observed hydrographs at Thomaston. It was concluded that the development of a flood at Torrington is comparatively uniform with the whole drainage area contributing about equal amounts per square mile.

D4. SPILLWAY DESIGN FLOOD

D4.1 Probable Maximum Precipitation. - Values of rainfall for the spillway design flood were obtained from Hydrometeorological Report No. 33 (April 1956). Losses from infiltration, surface detention, and transpiration and from intangible factors were assumed at the rate of 0.05 inch per hour. The probable maximum precipitation and rainfall excess for the Hall Meadow and East Branch reservoirs are tabulated in Table D - V. The rainfall excess was arranged in a pattern to give the most critical runoff conditions.

TABLE D - V

PROBABLE MAXIMUM PRECIPITATION

Time (Hours)	Max. Precip. (Inches)	Losses (Inches)	Rainfall Excess (Inches)
3	18.33	.15	18.18
6	4.20	.15	4.05
9	1.65	.15	1.50
12	1.05	.15	.90
15	.70	.15	.55
18	.55	.15	.40
21	.45	.15	.30

D4.2 Spillway Design Flood. - The spillway design flood inflows for Hall Meadow Brook and East Branch Reservoirs were developed from the probable maximum precipitation (Sec. D4.1) and the computed unit hydrographs. The computed inflows were routed through the reservoirs which were assumed to be filled to an elevation equivalent to 8 inches of storage when the flood runoff began. Table D-VI is a summary of the maximum discharges and elevations for the selected spillway lengths.

TABLE D - VI

SPILLWAY-DESIGN-FLOOD DATA

	Reservoir	
	Hall Meadow	East Branch
Drainage area (sq.mi.)	12.2	9.3
Peak inflow (c.f.s.)	33,000	25,000
Peak outflow (c.f.s.)	25,000	22,000
Pool elevation (feet) at beginning of flood (8 inches of storage)	883.5	864.
Spillway length (feet)	200	175
Spillway elevation (feet)	890	871
Surcharge (feet)	10	10
Freeboard (feet)	5	5
Top of dam (feet above m.s.l.)	905	886

D5. OUTLETS

The outlets for the Hall Meadow Brook and East Branch Dams will be ungated. The reservoirs will act as detention basins and flood flows exceeding the capacity of the outlet will be stored in the reservoir. Conduits with diameters of 45 inches at Hall Meadow and 38 inches at East Branch were selected to pass the normal flow of the river without utilizing too much storage; to limit the discharge for all reservoir stages to bankfull capacities; and to empty the reservoirs within a reasonable time.

D6. EFFECT OF RESERVOIR REGULATION

D6.1 Flood of August 1955. - The effectiveness of the proposed reservoirs on a recurring flood comparable to the flood of August 1955 is shown on Plates D - 2 and D - 3. The Hall Meadow Reservoir would reduce the flood discharge at the dam site from 6,170 c.f.s. to 270 c.f.s. At the time of the peak flow in Torrington from the uncontrolled watersheds the reservoir outflow through the ungated conduit would have been 220 c.f.s. The reservoir would rise to elevation 883, equivalent to 7.8 inches of storage or 70% of the total.

The flood discharge at East Branch Reservoir would have been decreased from 5,610 c.f.s. to 290 c.f.s. with only 250 c.f.s. contributing to the peak flows from uncontrolled areas. The reservoir would rise to elevation 863, equivalent to 7.7 inches of storage, or 73% of the total.

It is estimated that in a flood comparable to that of August 1955, the reservoirs would reduce the flood stages in Torrington by an average reduction of 4 feet in the East Branch and 3 feet on the West Branch and the Naugatuck below the East Branch.

D6.2 Standard Project Flood. - A standard project flood for Torrington was developed as a demonstration flood to test the effectiveness of the proposed reservoirs. This flood was developed for a drainage area of 47.6 square miles with rainfall as described in Civil Works Engineer Bulletin No. 52-8 and unit hydrographs developed from the flood of August 1955.

A tabulation of the 3-hour rainfall and rainfall excess is shown in Table D-VIII.

TABLE D - VIII

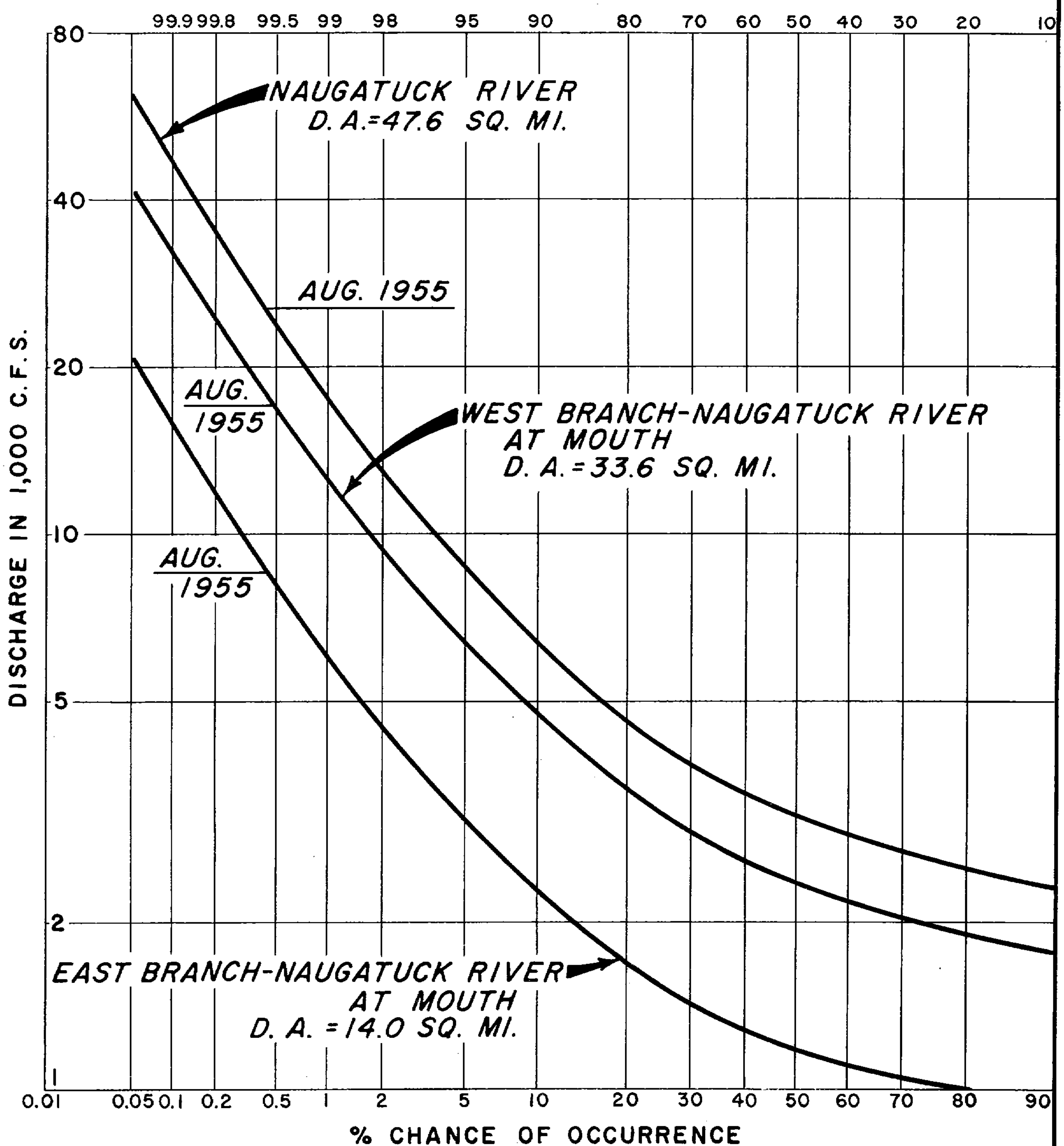
STANDARD-PROJECT-FLOOD RAINFALL
for Torrington

Time (Hours)	Drainage Area - 47.6 square miles Rainfall (Inches)	Losses (Inches)	Rainfall Excess (Inches)
0	0	0	0
3	0.07	0.07	0
6	.24	.21	0.03
9	.58	.21	.37
12	1.75	.21	1.54
15	6.97	.21	6.76
18	.97	.21	0.76
21	.28	.21	.07
24	.14	.14	0
	11.00	1.47	9.53

The peak discharge of the standard project flood at Torrington below the East Branch is 35,000 c.f.s., 33% greater than the experienced flood in

August. It should be noted that the total standard project storm of 11 inches is less than the rainfall experienced in August 1955. However, the rainfall intensities for the maximum 3-hour period in the standard project storm are approximately twice the maximum intensities experienced in 1955, thus producing higher discharges are produced in the standard project flood.

In the upper part of the Naugatuck River Basin, it is estimated that the Hall Meadow Brook Reservoir would reduce the flood flows in the West Branch by 36%, East Branch Reservoir would reduce flows on the East Branch by 71%, and the combination would reduce flood flows below the East Branch by 44%.

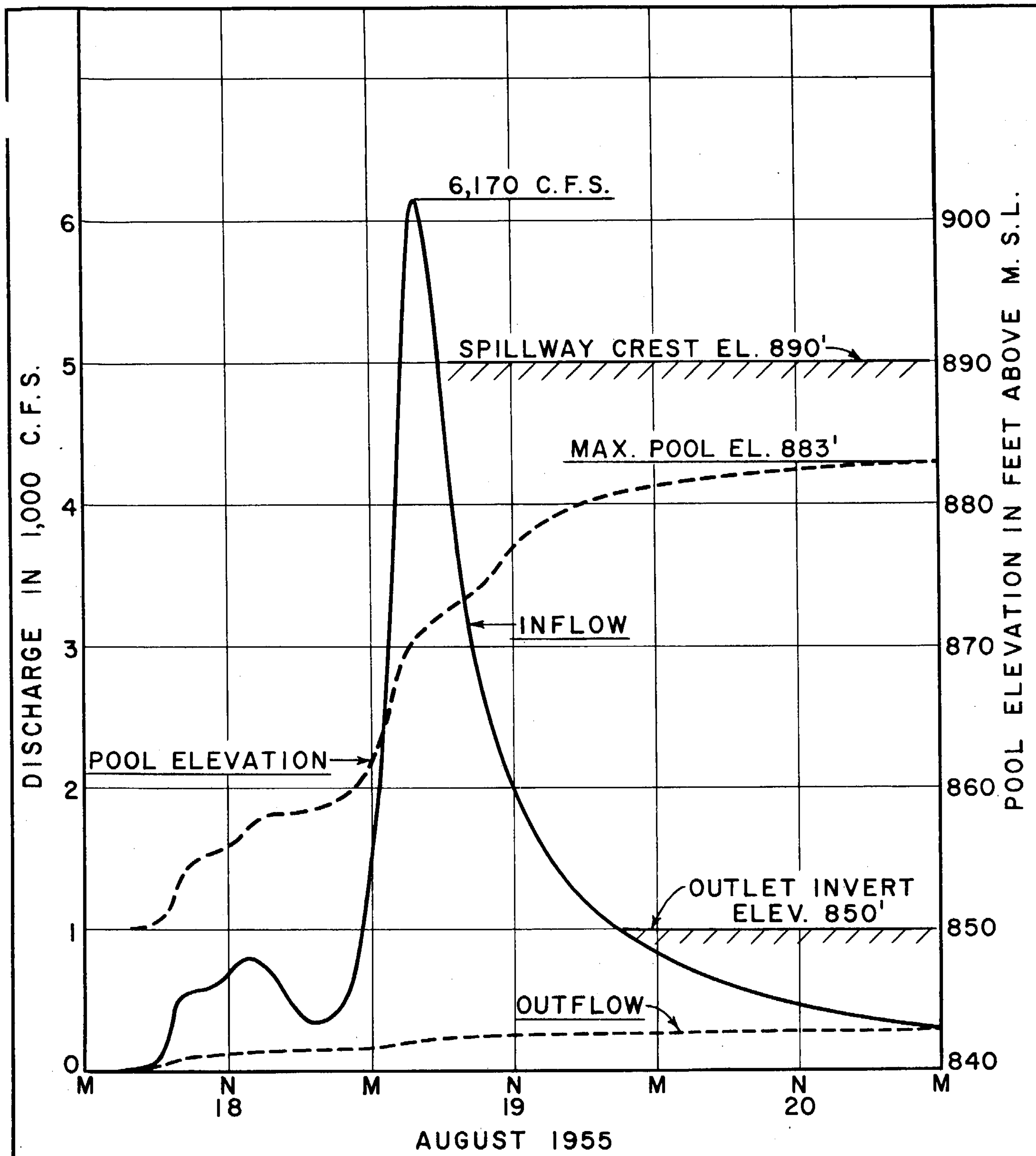


HOUSATONIC RIVER BASIN
NAUGATUCK RIVER WATERSHED

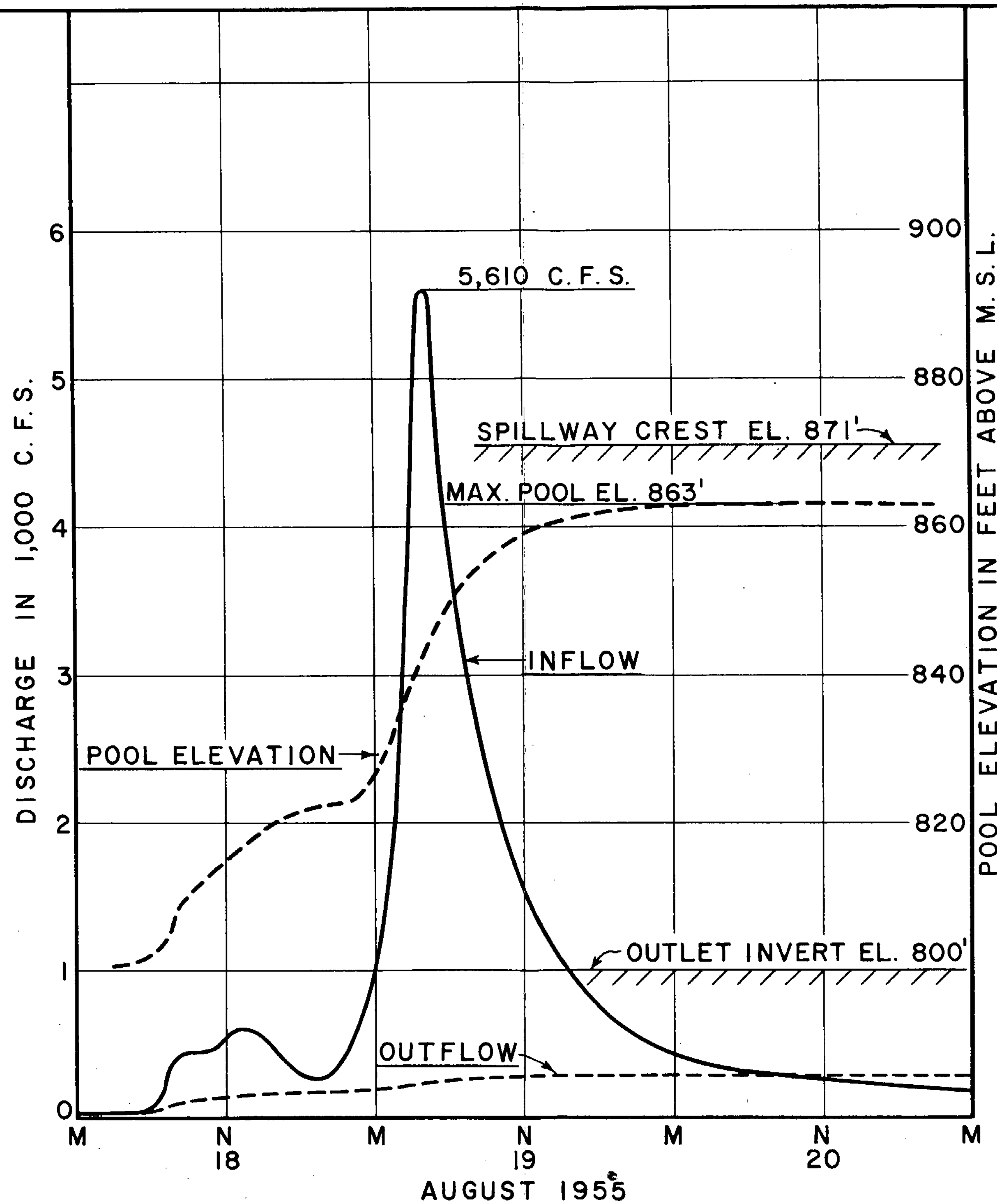
PEAK DISCHARGES
FREQUENCY CURVES
TORRINGTON, CONN.

CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS.

PLATE NO. D-1



HALL MEADOW BROOK RESERVOIR



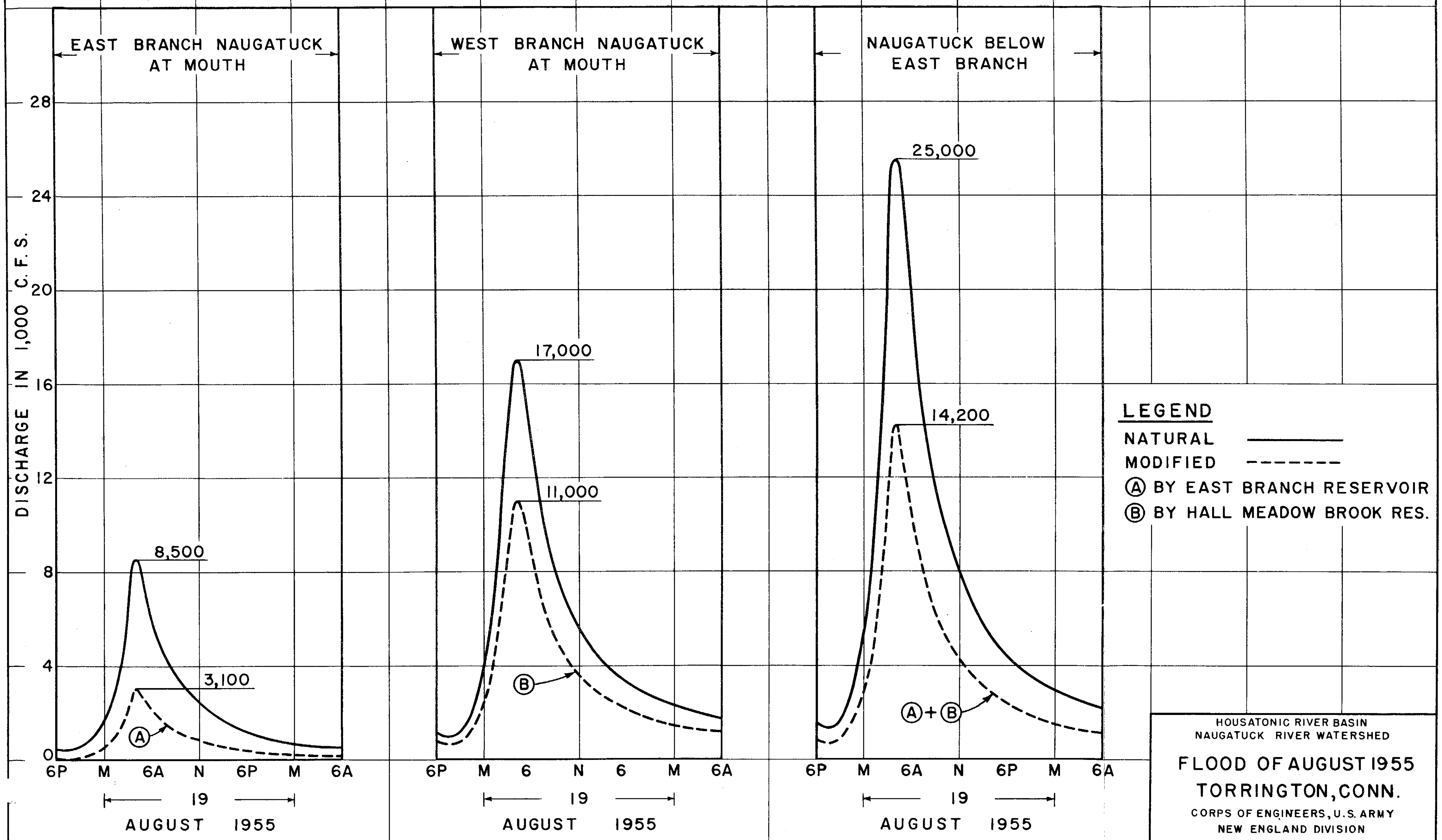
EAST BRANCH NAUGATUCK RESERVOIR

HOUSATONIC RIVER BASIN
NAUGATUCK RIVER WATERSHED

FLOOD OF AUGUST 1955
HALL MEADOW AND
EAST BRANCH RESERVOIRS

CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS.

PLATE NO. D-2



HOUSATONIC RIVER BASIN
NAUGATUCK RIVER WATERSHED

FLOOD OF AUGUST 1955
TORRINGTON, CONN.

CORPS OF ENGINEERS, U.S. ARMY
NEW ENGLAND DIVISION
BOSTON, MASS.

PLATE NO. D-3

APPENDIX E

DESIGN AND ESTIMATE OF COST

APPENDIX E

DESIGN AND ESTIMATE OF COST

APPENDIX E

DESIGN AND ESTIMATES OF COST

E1. SURVEYS AND EXPLORATIONS

Topographic maps of the dam sites and reservoir areas were compiled from U.S. Geological Survey and U.S. Army Map Service sheets. The principal geologic features were determined by core borings and field reconnaissance. An indication of soil conditions at each dam site was obtained by field inspection and by investigation of soil samples in the Soils Laboratory of the New England Division. Details of geologic and soils investigations and the results of laboratory tests for each site, with data on available construction materials, are given in Appendix A. Hydrologic and hydraulic data and details are contained in Appendix D.

E2. BASIS OF COST ESTIMATES

E2.1 Basis of Estimates. - The costs of Hall Meadow Brook and East Branch dams have been estimated upon the basis of a design which would provide economical and safe structures for the given conditions. Quantities have been estimated on the basis of net outlines of the proposed design and foundation requirements. Earth-borrow costs include stripping the borrow area, spoil, compactions in fill, and loss from borrow to fill. In determining rock quantities, consideration was given to rock available from the required excavation and to swell factor from excavation to fill.

E2.2 Unit Prices. - Unit prices are based on an average of bid prices, adjusted to 1956 price levels, for similar projects constructed, under construction, or under contract in New England. The adopted unit prices are adjusted to include minor items of work which do not appear in the cost estimate. The detailed cost estimates are given in Tables E-I and E-II.

E2.3 Contingencies, Engineering, and Overhead. - To cover contingencies, construction costs have been increased by 20%. The costs of engineering, design, supervision, and administration are estimated lump sums based on knowledge of the site and experience on similar projects.

E2.4 Lands and Damages. - Land requirements will include dam site, borrow, spoil, reservoir area, and land required for relocations. The costs of lands and rights-of-way have been estimated upon the basis of current market values, field reconnaissance, and information secured from local officials. The estimates are based on local interests paying costs for land, improvements, and rights-of-way.

E2.5 Basis of Annual Charges. - The estimate for annual charges is prepared on the basis of 2.5% interest on the total investment plus amortization of the investment over a period of 50 years. The Federal investment includes the first cost plus 2.5% interest for one-half the estimated construction period of 2 years. The total non-Federal annual charges include net loss of taxes on lands only. The maintenance of the projects is based on knowledge of the site and on similar projects in the New England area and is included as a non-Federal charge.

E3. DESCRIPTION AND COSTS - HALL MEADOW DAM AND RESERVOIR

E3.1 Description. - The Hall Meadow Brook dam site is located in the city of Torrington on Hall Meadow Brook, 0.4 mile above its confluence with the West Branch of the Naugatuck River. The reservoir, which would lie in the city of Torrington and the town of Goshen, is shown on Plate E-1. The total drainage area of this stream is 15.7 square miles. The drainage area at the dam site is approximately 12.2 square miles and is mostly cleared. The flood-control storage capacity of 7,200 acre-feet at spillway crest is equivalent to 11.4 inches of runoff from the tributary drainage area. The reservoir area would cover approximately 350 acres at spillway crest elevation 890.0 feet m.s.l.

E3.2 Dam and Appurtenant Works. - A rolled-earth dam would be constructed across the main channel of Hall Meadow Brook. An earth dike would be constructed across a saddle located about 1,000 feet east of the dam. An ogee spillway would be located at the westerly end of the dike with the spillway discharging into a tributary of Hall Meadow Brook. The outlet would consist of an ungated conduit discharging into the main channel of Hall Meadow Brook immediately below the dam. A general plan and typical sections of the dam and appurtenant structures are shown on Plate E-2.

Pertinent Data - Hall Meadow Brook Dam and Reservoir

Dam

Type	rolled earth
Top elevation	905 m.s.l.
Length	1080 feet
Maximum height	55 "
Freeboard above spillway design flood	5 "

Dike

Type	rolled earth
Top elevation	905 m.s.l.
Length	1030 feet
Maximum height	30 "

Spillway

Type	ogee
Crest elevation	890 m.s.l.
Length	200 feet
Design discharge	25,000 c.f.s.
Surcharge	10 feet

Outlet

Type	reinforced concrete, ungated
Size	45 inches diameter

E3.3 Relocations. - The proposed highway relocation will conform to current standards and requirements of the Connecticut State Highway Department and other interested agencies. The estimate is adequate to provide for reasonable modification in the plans.

The construction of the dam would necessitate the relocation of Connecticut Route 72 for a distance of 2.3 miles. The relocation would begin at a point about 0.5 mile downstream from the dam site and extend upstream along the reservoir flow line to rejoin Route 72 at a point about 2.0 miles upstream of the dam site.

E3.4 Plan of Construction. - During the first construction season, the highway would be relocated and the outlet works constructed. The river would be diverted early in the second season. The spillway channel excavation and dam and dike embankment would then be accomplished concurrently, followed by placing of spillway concrete. It is estimated that all work would be completed in two seasons.

E3.5 Cost Estimate. - Federal and non-Federal first costs of the Hall Meadow Brook Dam and Reservoir are detailed in Table E-1 at the end of this Appendix. Annual charges are given in Table I of the main report.

E4. DESCRIPTION AND COSTS: EAST BRANCH DAM AND RESERVOIR

E4.1 Description. - The East Branch dam site is located in the city of Torrington, Connecticut on the East Branch of the Naugatuck River. The reservoir, which would lie entirely within the limits of the city of Torrington, is shown on Plate E-3. The total drainage area of this stream is 14 square miles. The drainage area tributary to the dam site is approximately 9.3 square miles and is mostly wooded. The flood-control storage capacity is 5,150 acre-feet at spillway crest, equivalent to 10.5 inches of runoff from the tributary drainage area. The reservoir area would cover approximately 180 acres at the spillway crest elevation 871 feet m.s.l.

E4.2 Dam and Appurtenant Works. - A rolled-earth dam would be constructed across the main channel of the East Branch, Naugatuck River, with a side-channel spillway in the right abutment of the dam. The spillway channel would discharge into the river below the dam site.

The outlet would consist of an ungated conduit discharging into the main channel of the East Branch below the dam. A general plan and typical sections of the dam and appurtenant structures are shown on Plate E-4.

Pertinent Data - East Branch Dam and Reservoir

Dam	
Type	rolled earth
Top elevation	886 m.s.l.
Length	740 feet
Maximum height	95 "
Freeboard above spillway design flood	5 "
Spillway	
Type	side channel
Crest elevation	871 m.s.l.
Length	175 feet
Design discharge	22,000 c.f.s.
Surcharge	10 feet
Outlet	
Type	Reinforced concrete, ungated
Size	38 inches diameter

E4.3 Relocations. - The construction of the dam would necessitate the relocation of Newfield Road for a distance of about 2.0 miles. The relocation would begin at the junction of Newfield Road and Marshall Lake Road, Torrington, at the upstream end of the proposed reservoir. It would cross Meyer Road and roughly follow the flow line back to Newfield Road, about 2,000 feet downstream from the dam.

E4.4 Plan of Construction. - During the first construction season the highway would be relocated and the outlet works constructed. The river would be diverted early in the second season. The spillway channel excavation and dam embankment work would then be accomplished concurrently, followed by placing of spillway concrete. It is estimated that all work would be completed in two seasons.

E4.5 Cost Estimates. -Federal and non-Federal first costs of the East Branch Dam and Reservoir are detailed in Table E-II at the end of this Appendix. Annual charges are given in Table II of the main report.

TABLE E-1 - HALL MEADOW BROOK DAM AND RESERVOIR

FIRST COSTS
(1956 Price Level)

	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
FEDERAL FIRST COST					
		RELOCATIONS			
Roads	2.3	Mi	L.S.	$ 400,000	
Contingencies				70,000	
Total					$ 470,000
		RESERVOIR			
Reservoir Clearing	120	Acre	350.00	42,000	
Contingencies				8,000	
Total					50,000
		ACCESS ROAD			
Access Road			L.S.	5,000	
Contingencies				1,000	
Total					6,000

	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
			DAM CONSTRUCTION		
Preparation of Site	17	Acre	$600.00	10,200	
Stream Control	1	Job	L.S.	5,000	
Earth Excavation (Common)	180,000	c.y.	0.60	108,000	
Earth Excavation (Borrow)	98,400	c.y.	0.75	73,800	
Rock Excavation	8,800	c.y.	3.50	30,800	
Rock Excavation (Borrow)	45,000	c.y.	4.00	180,000	
Embankment, Rolled	243,000	c.y.	0.30	72,900	
Filter Sand and Gravel	5,000	c.y.	3.00	15,000	
Rock Fill	64,000	c.y.	0.80	51,200	
Concrete Mass	6,000	c.y.	35.00	210,000	
Concrete Reinforced	200	c.y.	65.00	13,000	
Conduit	1	Job	L.S.	105,000	
Miscellaneous Items				87,500	
Subtotal				$ 962,400	
Contingencies				193,600	
Total Dam				1,156,000	
Engineering and Design				186,000	
Supervision and Inspection				92,000	
Total Federal First Cost				$ 1,960,000	

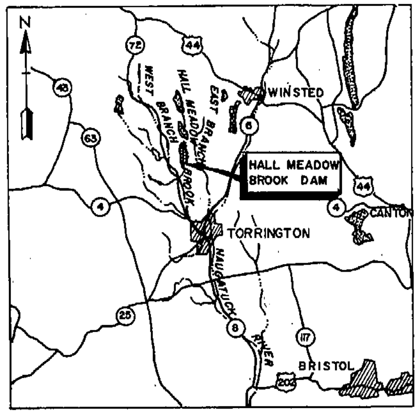
	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
NON-FEDERAL FIRST COST					
LANDS AND DAMAGES					
Lands	465	Acre	L.S.	$ 178,000	
Improvements Acquired			L.S.	184,000	
Severance Damages				7,000	
Subtotal				$ 369,000	
Contingencies				72,000	
Subtotal				$ 441,000	
Resettlement Costs			L.S.	8,000	
Acquisition Costs			L.S.	11,000	
Total Non-Federal First Cost					460.000
Total Federal First Cost					1,960,000
TOTAL PROJECT FIRST COST					$ 2,420,000

TABLE E-II - EAST BRANCH DAM AND RESERVOIR

FIRST COSTS
(1956 Price Level)

	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
FEDERAL FIRST COST					
		RELOCATIONS			
Roads	2.0	Mi.	L.S.	$ 310,000	
Contingencies				60,000	
Total					$ 370,000
		RESERVOIR CLEARING			
Reservoir Clearing	25	Acre	360.00	9,000	
Contingencies				2,000	
Total					11,000
		ACCESS ROADS AND PARKING AREA			
Access Road			L.S.	5,000	
Contingencies				1,000	
Total					6,000
		DAM CONSTRUCTION			
Site Preparation	9	Acre	600.00	5,400	
Stream Control	1	Job	L.S.	5,000	
Earth Excavation (Common)	174,000	c.y.	0.60	104,400	
Earth Excavation (Borrow)	95,750	c.y.	0.75	71,812	
Rock Excavation	63,000	c.y.	3.50	220,500	
Embankment Rolled	272,000	c.y.	0.30	81,600	
Filter Sand & Gravel	10,000	c.y.	3.00	30,600	
Rock fill	50,000	c.y.	0.80	40,000	
Concrete Mass	3,700	c.y.	35.00	129,500	
Conc., Reinforced	500	c.y.	65,000	32,500	
Conduit	1	Job	L.S.	124,000	
Miscellaneous Items				84,688	
Subtotal				930,000	

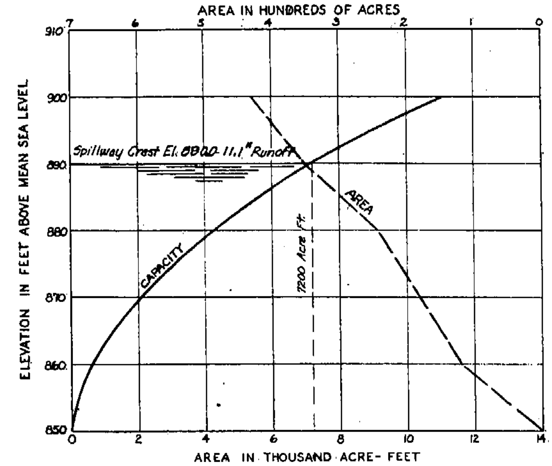
	Estimated Quantity	Unit	Price	Amount	Total
FEDERAL FIRST COST (cont'd)					
Subtotals carried forward				$ 930,000	$ 387,000
Contingencies				100,000	
Total, Dam					1,120,000
Engineering and Design					183,000
Supervision and Inspection					90,000
Total Federal First Cost					$ 1,780,000
NON-FEDERAL FIRST COST					
LANDS AND DAMAGES					
Land	235	Acre	L.S.	$ 72,000	
Improvements			L.S.	613,000	
Severance Damages			L.S.	10,000	
Subtotal				$ 695,000	
Contingencies				143,000	
Subtotal				838,000	
Resettlement Costs			L.S.	24,000	
Acquisition Costs			L.S.	28,000	
Total Non-Federal First Cost					890,000
TOTAL PROJECT FIRST COST					$ 2,670,000



VICINITY MAP

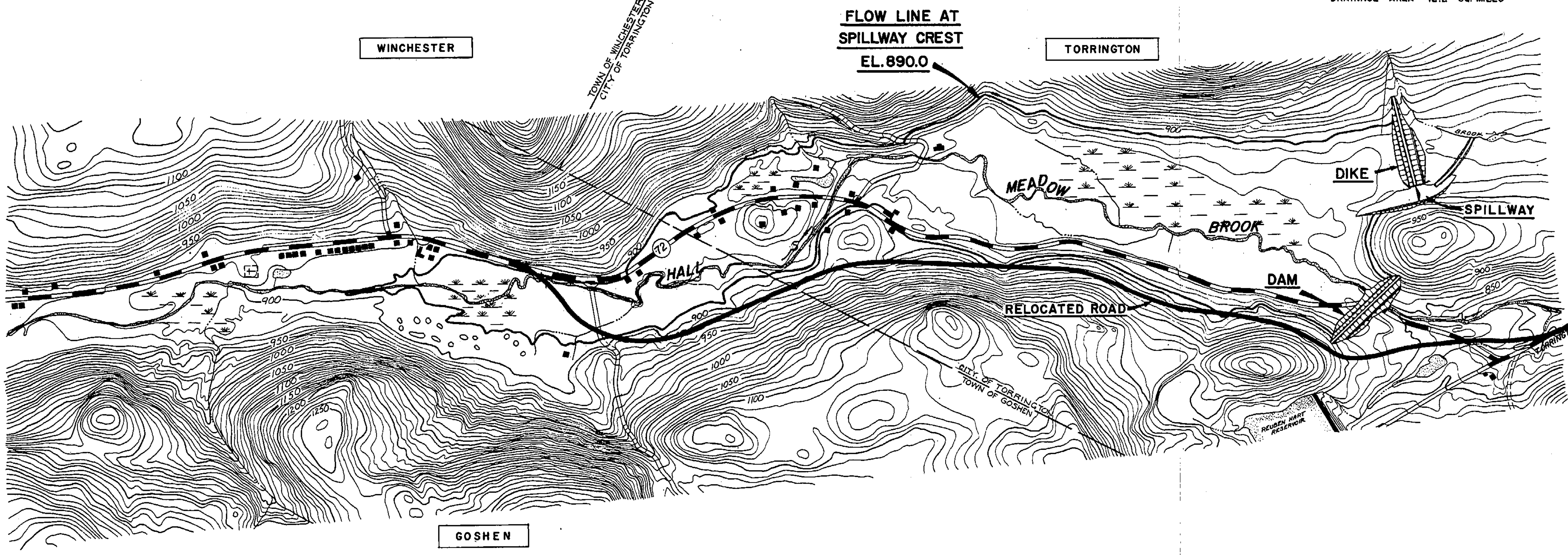
SCALE IN MILES

5 0 5 10



AREA AND CAPACITY CURVES

DRAINAGE AREA 12.2 SQ. MILES



LEGEND

- Existing gravel roads
- Surfaced Town roads
- Civil Township Line
- Reservoir at spillway crest, El. 890
- Relocated road
- State highway

RESERVOIR PLAN

SCALE IN FEET

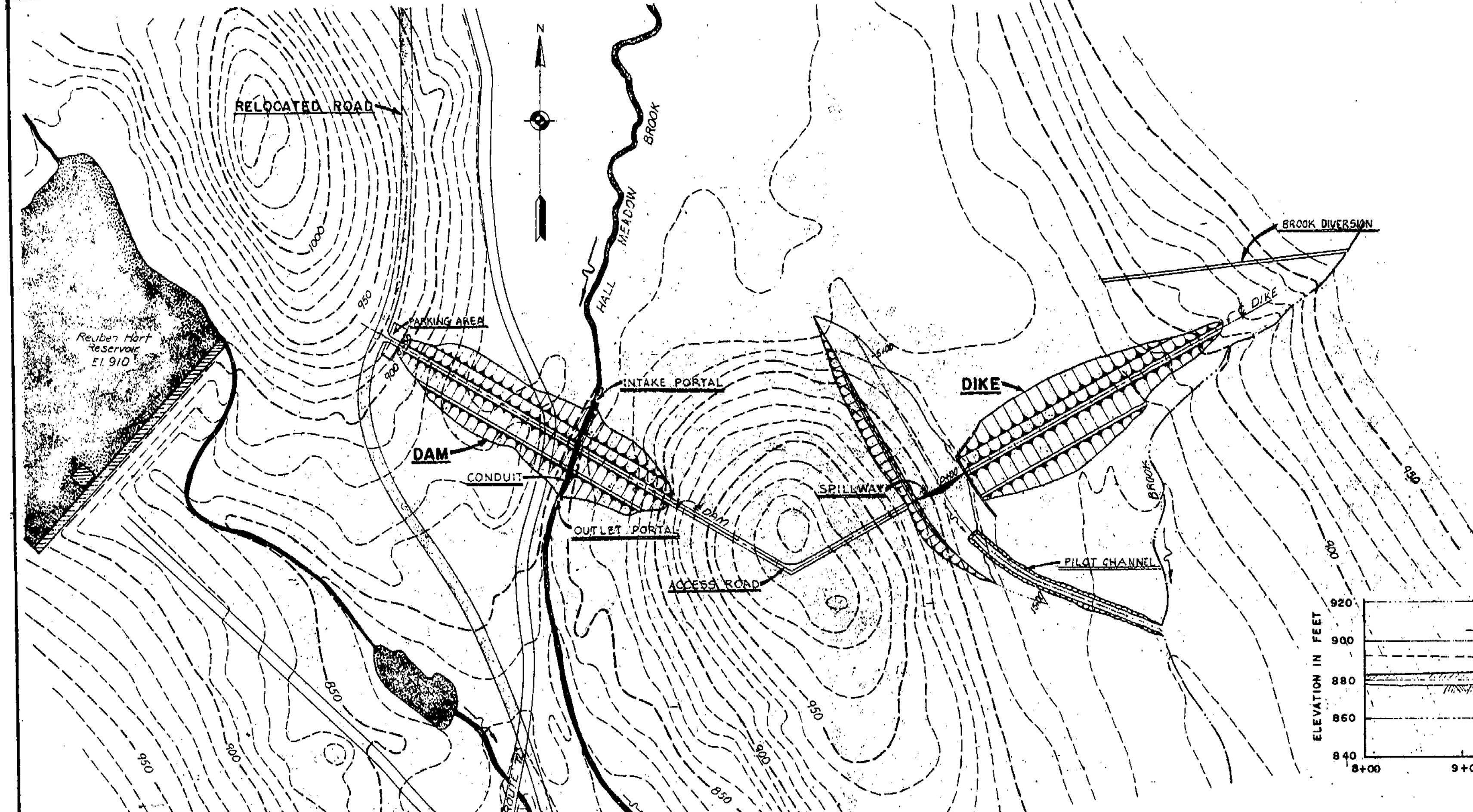
0 500' 1000' 1500'

NOTES

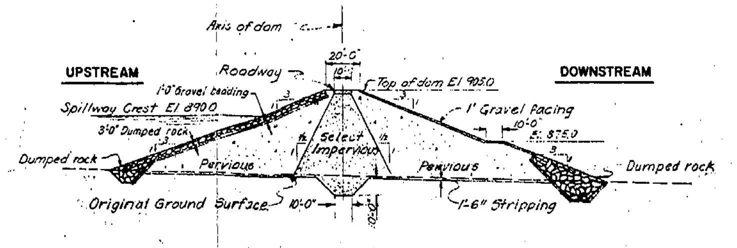
Elevations refer to Mean Sea Level Datum
Contour interval equals ten feet
Topography is based on U.S.G.S. Map

CORPS OF ENGINEERS, U. S. ARMY OFFICE OF THE DIVISION ENGINEER NEW ENGLAND DIVISION BOSTON, MASS.		
DR. BY HHL. / TR. BY HHL / CK. BY HEB	HOUSATONIC RIVER FLOOD CONTROL	
PROJECT ENGINEER	HALL MEADOW BROOK DAM RESERVOIR MAP	
SUBMITTED BY: CHIEF, PLANN. & RPTS BRANCH	HALL MEADOW BROOK	CONNECTICUT
APPROVED: CHIEF, ENGINEERING DIV.	APPROVED: LT. COL. C.E. ASST. TO DIVISION ENGINEER	DATE MAY 1956
TO ACCOMPANY REPORT DATED 31 MAY 1956	SCALE: AS SHOWN	DRAWING NUMBER HC-1-1028 SHEET 1 OF 2

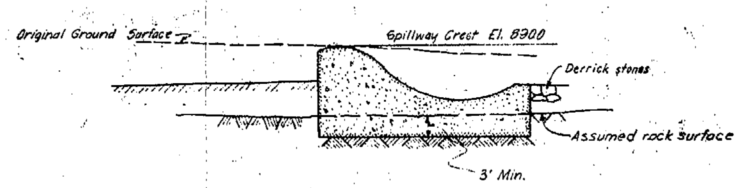
CORPS OF ENGINEERS U.S. ARMY



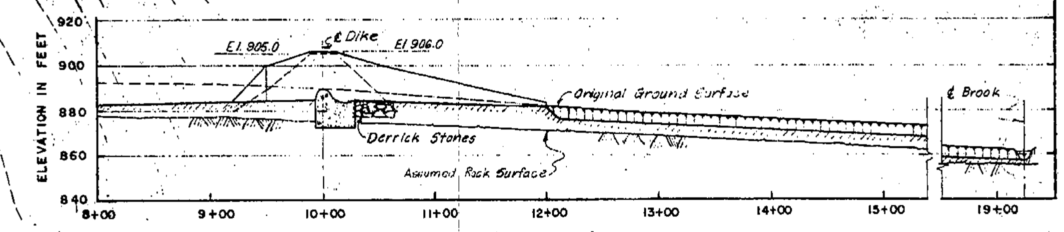
PLAN
SCALE 1" = 200'



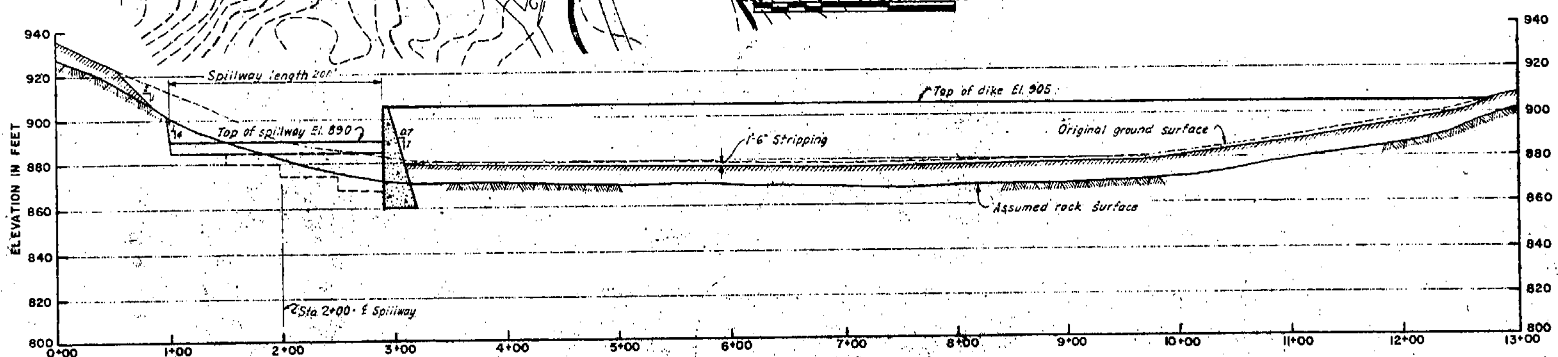
TYPICAL DAM & DIKE SECTION
SCALE 1" = 40'



SECTION THRU SPILLWAY
SCALE 1" = 10'



PROFILE ALONG ℄ SPILLWAY
SCALE: HOR. 1" = 60', VERT. 1" = 30'



PROFILE ALONG ℄ DIKE
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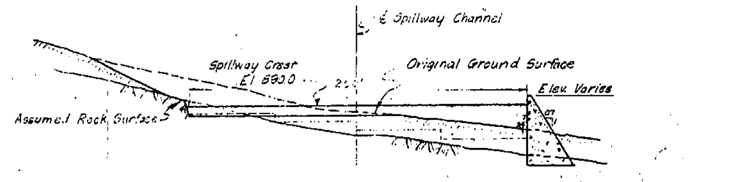
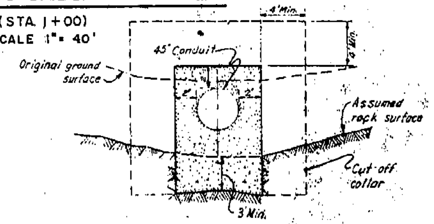
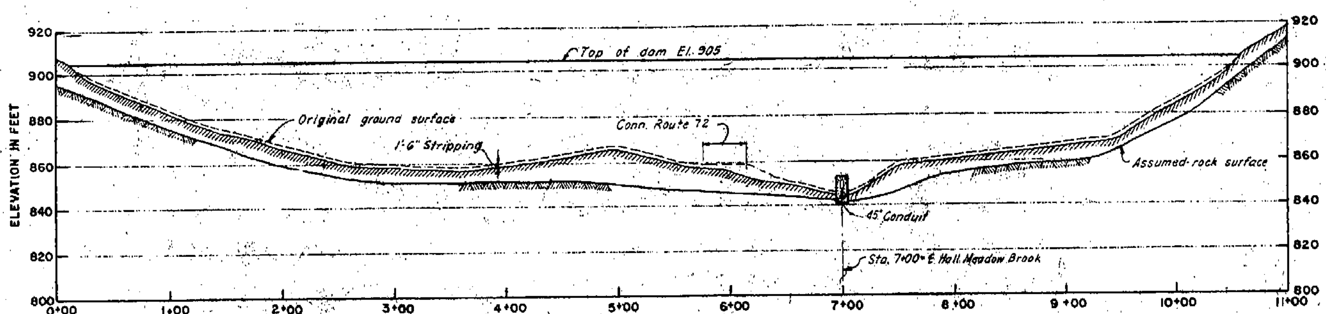


SECTION THRU SPILLWAY CHANNEL
(STA. 1+00)
SCALE 1" = 40'



SECTION THRU CONDUIT
SCALE 1" = 6'



PROFILE ALONG ℄ DAM
SCALE HOR. 1" = 60', VERT. 1" = 30'

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
H.H.L.	B.G.	H.E.B.

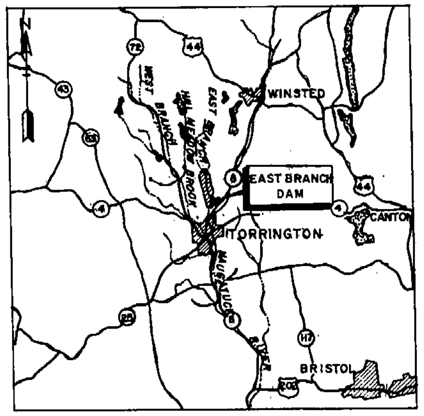
HOUSATONIC RIVER FLOOD CONTROL
HALL MEADOW BROOK DAM
GENERAL PLAN
HALL MEADOW BROOK CONNECTICUT

PROJECT ENGINEER
SUBMITTED BY:
CHIEF, PLANN. & R'PT'S BRANCH
APPROVED:
CHIEF, ENGINEERING DIV.
APPROVED:
LT. COL. C.E. ASS'T TO DIVISION ENGINEER
DATE MAY 1956
SCALE AS SHOWN

TO ACCOMPANY REPORT DATED 31 MAY 1956

DRAWING NUMBER HC-1-1029
SHEET 2 OF 2

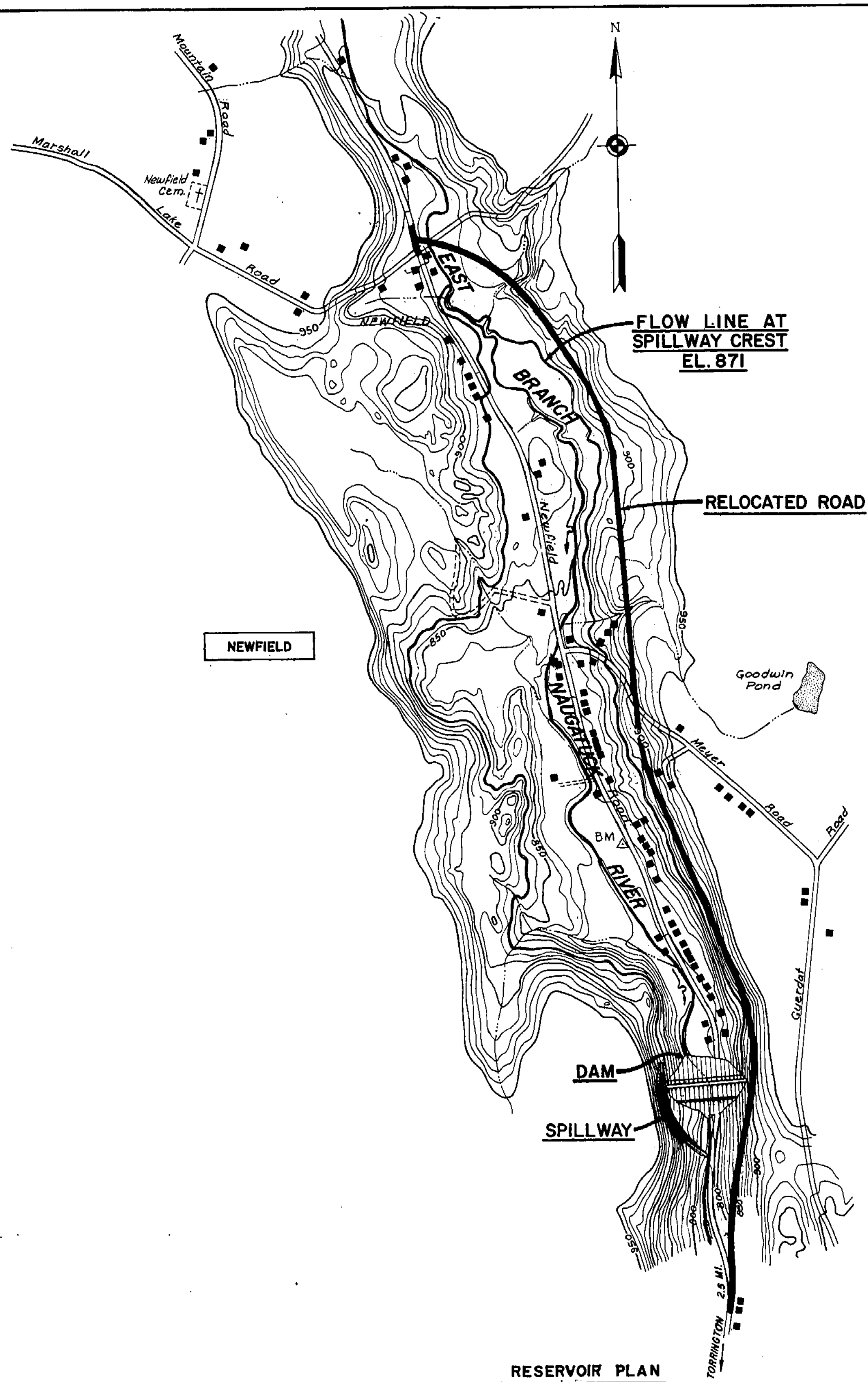
PLATE NO. E-2



VICINITY MAP

SCALE IN MILES

5 0 5 10



RESERVOIR PLAN

SCALE IN FEET

0 500' 1000' 1500'

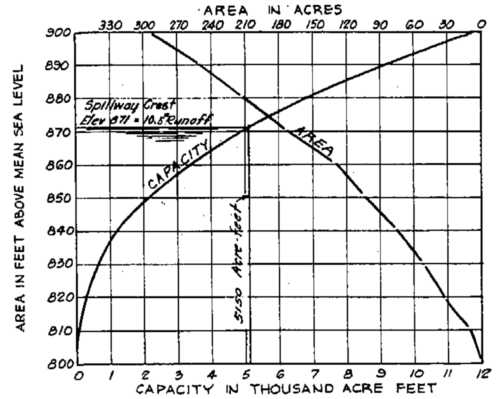
LEGEND

Existing gravel roads

Surfaced Town roads

Reservoir at spillway crest, El. 871

Relocated road



AREA AND CAPACITY CURVES

DRAINAGE AREA 9.25 SQ. MILES

NOTES

Elevations refer to Mean Sea Level Datum.

Contour interval equals ten feet.

Topography is based on U.S.G.S. Map.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
R.F	R.F	H.E.B

V. A. Sl[illegible], Jr.
PROJECT ENGINEER

SUBMITTED BY:
CHIEF, PLANN. & RPTS BRANCH

APPROVED:
CHIEF ENGINEERING DIV.

HOUSATONIC RIVER FLOOD CONTROL

EAST BRANCH DAM

RESERVOIR MAP

NAUGATUCK RIVER CONNECTICUT

APPROVED:
LT.COL. C.E. ASS'T. TO DIVISION ENGINEER

DATE MAY 1956

SCALE: AS SHOWN

TO ACCOMPANY REPORT DATED 31 MAY 1956

DRAWING NUMBER HC-1-1030

SHEET 1 OF 2

CORPS OF ENGINEERS U.S. ARMY

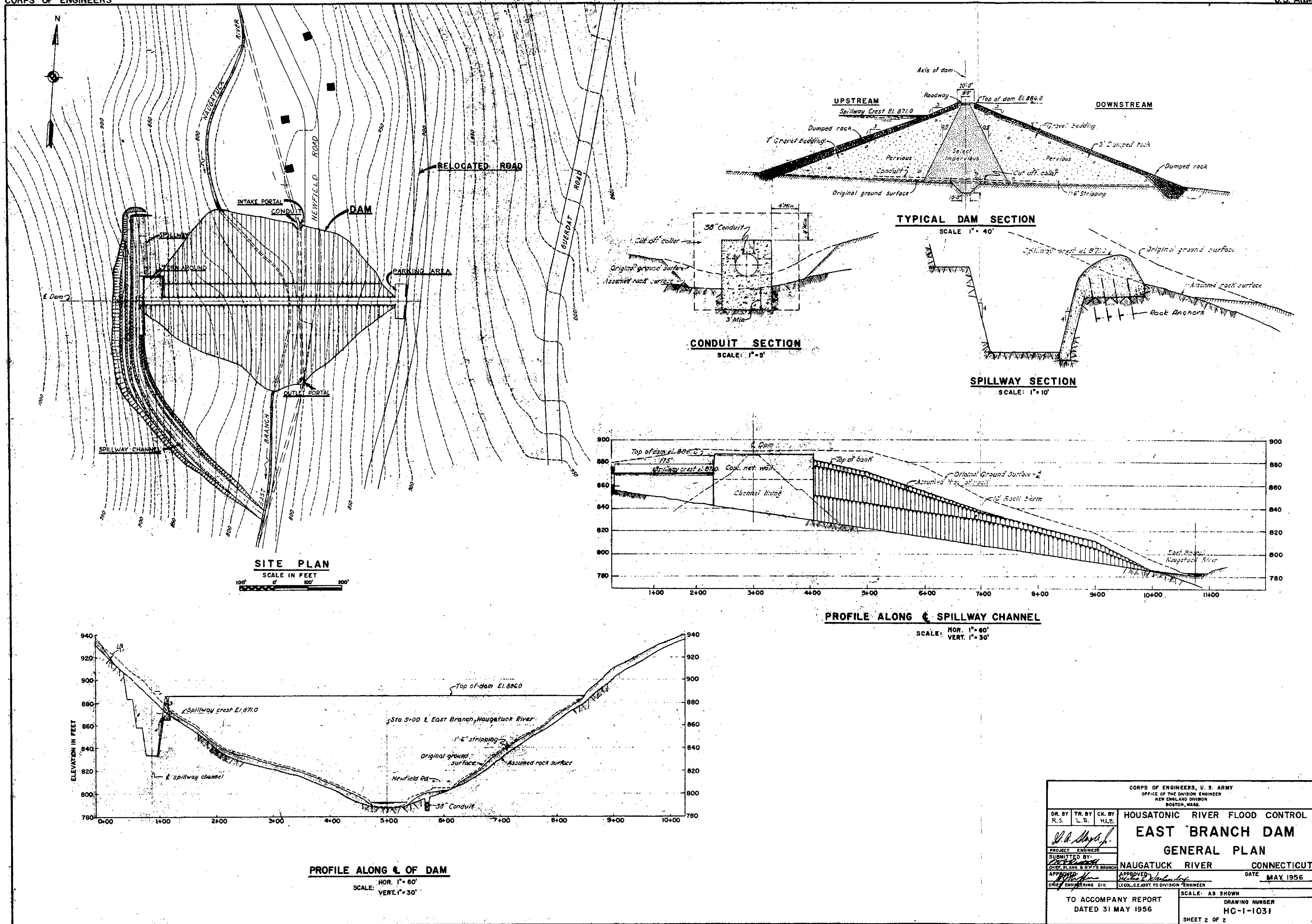


PLATE NO. E-4

SYLLABUS

The Division Engineer finds that there is need for revision of the existing flood control plan for the Naugatuck River in order to insure the stability of present development, the security of the inhabitants, and the preservation of existing economic values. He finds that the Naugatuck River causes major damages along its watercourse through the highly industrialized Naugatuck Valley. He concludes that flood control measures, in addition to the authorized reservoirs, are necessary and economically justified.

The Division Engineer recommends that the authorized plan for flood control in the Naugatuck River Basin be modified to provide for the construction of flood control dams and reservoirs on Northfield Brook, Branch Brook, Hancock Brook, and Hop Brook at a total estimated first cost to the United States of $10,130,000 exclusive of pre-authorization costs, provided local interests establish encroachment lines downstream of the dams to permit reasonable, efficient reservoir operation.

(R 11/1/58)

entire course through the town. Nearly 350 residential and commercial buildings in Naugatuck were damaged and some 40 of these were destroyed.

29. ANSONIA, CONNECTICUT

Flooded by the heavy flow on the Naugatuck River, Ansonia suffered losses of over $29,000,000. Two lives were lost as approximately 150 dwellings, 270 commercial establishments, and some 6 public buildings were flooded to depths up to 12 feet. Severe urban losses were experienced in the Main Street area when the Maple Street bridge washed away and the attendant surge released the mound of debris acting as a temporary dam. Damage to 5 Ansonia firms exceeded $20,000,000. Hardest hit were the Hershey Metal Products Corporation and the Ansonia divisions of the American Brass Company and the Farrel-Birmingham Company, with plants in the central part of the city. Located in low areas, these plants sustained heavy structural damage and heavy silting of machinery and finished products.

30. RECURRING LOSSES

Under economic conditions prevailing in 1958, a recurrence of the August 1955 flood after discharge reductions by Thomaston, Hall Meadow, and East Branch Reservoirs and the P.L. 685 project at Waterville-Waterbury would cause an estimated loss of $28,560,000 in the main damage zones of the lower Naugatuck River Basin. Approximately $9,350,000 of this loss would occur in the Waterbury area and nearly $11,000,000 in the Ansonia-Seymour area.

31. AVERAGE ANNUAL LOSSES

Average annual losses remaining in the lower Naugatuck River Basin after reductions by the above projects amount to $1,098,000.

SECTION XII - EXISTING CORPS OF ENGINEERS' FLOOD CONTROL PROJECTS

32. THOMASTON DAM AND RESERVOIR

This project was authorized by the Flood Control Act approved December 22, 1944 (Public Law 534, 78th Congress, 2d session). The site of the Thomaston Reservoir is on the Naugatuck River about 30 miles above its confluence with the Housatonic River and about 1½ miles north of Thomaston. The reservoir will extend upstream approximately 7 miles. The project provides for the construction of a rolled earth and rockfill dam 2,000 feet long at the crestline, rising 142 feet above the stream bed and providing a storage capacity of 42,000 acre-feet, equivalent to 8.1 inches of runoff from its tributary drainage area of 97.0 square miles. A side-channel spillway with a low concrete weir, constructed in rock, will be located in the left abutment of the dam. The outlet will consist of a 10-foot diameter concrete horseshoe conduit. Control will be accomplished by 2 hydraulically-operated slide gates. A contract for relocation of the railroad from the reservoir area was awarded in October 1957. A contract for construction of the dam was awarded in April 1958 with the project scheduled for completion in 1960. Estimated costs, as of the last printed Annual Report of the Chief of Engineers (1957), are $8,920,000 for construction and $8,580,000 for lands and damages, including highway, railroad, and utility relocations; a total of $17,500,000 for new work.

33. PUBLIC LAW 685 PROJECTS

Pursuant to the provisions of Section 205 of the Flood Control Act of 1948, as amended by Public Law 685, 84th Congress, 2d session, approved July 11, 1956, the Chief of Engineers has authorized studies of 5 local protection projects in the Naugatuck River Basin. These projects are described in the following paragraphs.

a. <u>Torrington</u>.

(1) <u>East Branch and Naugatuck Rivers</u>. This project consists of channel straightening, deepening, and widening, and construction of intermittent earth dikes and flood walls along the East Branch of the Naugatuck River and the main Naugatuck River below its confluence with the West Branch. Within the project length of approximately 9,000 feet, the new channel in the Naugatuck River has a bottom width of 130 feet; the channel in the East Branch has a bottom width of 50 feet from the confluence with the West Branch to the plant of the Connecticut Power Company, and a width of 30 feet for the remainder of the improvement. Dikes, composed of materials excavated from the channel, were constructed along portions of both banks of the improved channel. Several short sections of concrete retaining wall were constructed, together with minor repairs to

SECTION XVIII - ANNUAL BENEFITS

48. FLOOD PREVENTION BENEFITS

Flood damage prevention benefits represent the difference between the average annual losses of $1,098,000 remaining in the lower Naugatuck River Basin after discharge reductions by Thomaston, Hall Meadow, and East Branch Reservoirs and the P. L. 685 project at Waterville-Waterbury, and the average annual losses remaining after addition of 4 reservoirs on Northfield, Branch, Hancock, and Hop Brooks. Flood damage prevention benefits accruing to the 4 reservoirs amount to $639,000. A summary of annual flood prevention benefits is presented below.

Average Annual Flood Prevention Benefits
(1958 prices)

Northfield Brook Dam and Reservoir	$120,000
Black Rock Dam and Reservoir	225,000
Hancock Brook Dam and Reservoir	153,000
Hop Brook Dam and Reservoir	141,000
Total Annual Benefits	639,000

In addition to the tangible flood damage prevention benefits, important intangible benefits would accrue to the 4 reservoir projects through the reduction of the threat to life and of the potential danger of disease from polluted floodwaters.

49. ENHANCEMENT BENEFITS

Flood discharge and consequent flood stage reductions by the reservoir system would encourage higher utilization of downstream lands and buildings. The degree and form of such higher utilization, however, is conjectural. No higher utilization or enhancement benefits have, therefore, been assigned to the reservoir system.

SECTION XIX - PROJECT FORMULATION AND ECONOMIC JUSTIFICATION

50. GENERAL

Benefits for each of the 9 reservoirs studied in detail were first determined for each reservoir acting alone. Benefits attributable to the authorized Thomaston Reservoir, the P. L. 685 project at Waterville-Waterbury, and the previously recommended Hall Meadow Brook and East Branch Reservoirs were considered to be already realized and were, therefore, not eligible for redistribution among any of the projects under study. An analysis on this basis indicated 4 of the 9 projects under study had benefit-cost ratios of less than unity. Since this was the most favorable basis of consideration, these 4 projects were dropped from further study. Two projects on Branch Brook, the Black Rock project and the Branch Brook project, were alternatives having the same benefits. Since costs were substantially less for Black Rock than for Branch Brook, this latter site was dropped from further consideration. Benefits to each of the 4 remaining reservoirs in the system, based on respective flood control effectiveness, resulted in favorable benefit-cost ratios for all 4. As a final test of economic feasibility, benefits for each reservoir acting last in the system were determined. Under this stringent criteria, all 4 reservoirs had a benefit-cost ratio in excess of unity.

Table 8 gives pertinent data on the reservoirs in the proposed comprehensive plan and on other reservoirs studied.

TABLE 8

SUMMARY OF RESERVOIRS - NAUGATUCK RIVER BASIN

NAME	LOCATION: RIVER	LOCATION: TOWN	DRAINAGE AREA (Sq Miles)	FLOOD CONTROL CAPACITY (Acre-Ft)	FLOOD CONTROL CAPACITY (Inches)	FIRST COSTS: CONSTRUCTION $	FIRST COSTS: RELOCATIONS $	FIRST COSTS: LANDS $	FIRST COSTS: TOTAL $	ANNUAL CHARGES $	ANNUAL BENEFITS $	BENEFIT-COST RATIO
					COMPREHENSIVE PLAN							
Hall Meadow[1] Brook	Hall Meadow Brook	Torrington	12.2	7,200	11.4	1,412,000	548,000	460,000[2]	2,420,000	100,000	244,000	2.44
East Branch[1]	E. Branch Naugatuck	Torrington	9.3	5,150	10.5	1,343,000	437,000	890,000[2]	2,670,000	102,000	128,000	1.25
Thomaston[3]	Naugatuck	Thomaston	97.0	42,000	8.1	8,920,000	6,784,000	1,796,000	17,500,000	674,000	3,058,000	4.54
Northfield Brook	Northfield Brook	Thomaston	5.7	2,430	8.0	1,108,000	362,000	150,000	1,620,000	64,300	120,000	1.87
Black Rock	Branch Br	Thomaston	20.8	8,860	8.0	2,415,000	707,000	428,000	3,550,000	141,100	225,000	1.59
Hancock Brook	Hancock Br	Plymouth	12.0	3,820	6.0	756,000	1,316,000	448,000	2,520,000	98,200	153,000	1.56
Hop Brook	Hop Brook	Middlebury	16.0	6,840	8.0	911,000	467,000	1,122,000	2,500,000	109,600	141,000	1.29
Totals						16,865,000	10,621,000	5,294,000	32,780,000	1,289,200	4,069,000	3.16
					OTHER RESERVOIRS STUDIED							
Branch Brook[4]	Branch Br	Thomaston	22.8	10,000	8.4	2,135,000	787,000	1,716,000	4,638,000	203,500	225,000[5]	1.11
Scovill	Mad River	Wolcott	8.2	3,719	8.5	2,705,000	137,000	634,000	3,476,000	141,700	105,500[6]	0.74
Meadow Pond Brook	Meadow Pond Br	Naugatuck	6.5	2,090	6.0	921,000	364,000	605,000	1,890,000	80,700	66,900[6]	0.83
Bladens River	Bladens R	Seymour	10.0	6,000	11.25	2,030,000	848,000	1,230,000	4,108,000	174,500	25,800[6]	0.15
Little River	Little R	Oxford	12.20	4,620	7.1	1,389,000	698,000	665,000	2,752,000	109,800	35,100[6]	0.32

(1) Recommended in Interim Report, printed as H.Doc. 31, 85th Congress
(2) Local costs
(3) Under construction - costs from 1957 Annual Report
(4) Alternative to Black Rock
(5) Benefits acting in 7-reservoir system in place of Black Rock
(6) Benefits acting alone after reductions by Thomaston

SECTION XX - PROPOSED LOCAL COOPERATION

51. GENERAL

No local participation in the cost of any of the reservoirs under consideration is required since all projects will be operated solely for flood control and will provide basinwide benefits. However, local interests should be required to zone the channels downstream of the proposed dams to prevent encroachment which would be harmful or detrimental to reasonable, efficient reservoir operation. The State of Connecticut now has such a law and has established encroachment lines on the main stem of the Naugatuck River (see paragraph 36). Similar encroachment lines should be extended up the tributaries to the proposed dam sites.

(R 11/1/58)

SECTION XXIII - CONCLUSIONS AND RECOMMENDATIONS

55. CONCLUSIONS

Periodic flood discharges produce major damages in the highly industrialized Naugatuck River Basin. The area will continue to face this threat after completion of the authorized Thomaston Reservoir.

Additional protection can be provided by construction of flood control reservoirs on tributaries of the Naugatuck River. The proposed plan of reservoirs would afford a high degree of protection and is economically justified. Local protection projects in lieu of or in addition to the proposed plan are not economically justified at this time, with the possible exception of small projects being or to be considered under authority of Public Law 205 of the 1948 Flood Control Act as amended by Public Law 685, 84th Congress, and local protection at Ansonia. A supplemental report will be prepared on Ansonia.

Multiple-purpose use of any of the proposed projects is not economically justified at this time.

56. RECOMMENDATIONS

It is recommended that the plan for the control of floods in the Naugatuck River Basin, approved by the 1944 Flood Control Act (Public Law 534, 78th Congress), be modified to provide for the construction of flood control dams and reservoirs on Northfield Brook, Branch Brook, Hancock Brook, and Hop Brook, all substantially in accordance with plans described in this report, at a total estimated first cost to the United States of $10,130,000 exclusive of preauthorization costs, and annual costs of $30,000 for maintenance and operation, providing local interests establish encroachment lines downstream of the dams to permit reasonable, efficient reservoir operation.

Att.
10 Report Plates
6 Appendices

ALDEN K. SIBLEY
Brigadier General, U. S. Army
Division Engineer

(R 11/1/58)

peak at the U. S. G. S. gage near Naugatuck, Connecticut. The relative difference in timing of these floods is very small despite the wide range in flood magnitudes. This characteristic reflects the rapid development of the flood on the main river, and is produced by the many tributaries literally "dumping" their contents into the main channel almost simultaneously through the entire valley. With no storage available, this water in the main channel rises very quickly until the water surface is nearly parallel with the steep gradient of the river bed. The hydraulic characteristics of the river channel change with the rapid rise in river stages, thus creating high destructive velocities throughout the entire river. In the August 1955 flood, debris dams were formed temporarily at constrictions, further raising the flood stages. Failure of these temporary dams produced surges which undoubtedly caused chain reactions downstream, further aggravating the already critical conditions.

(3) Source of floods. - The source or origin of floods above each damage center was determined in order to establish the value of upstream reservoirs. A summary of the discharge contributions from selected areas to the flood peaks at Torrington, Thomaston, Waterbury, Naugatuck, and Ansonis is tabulated in Table B-6 and shown graphically on Plates B-5 and B-6.

d. Standard project flood. - The standard project flood developed for the Naugatuck River was based on the standard project storm rainfall as described in Civil Engineer Bulletin No. 52-8, and in unit hydrographs derived from analyses of record floods.

(1) Standard project storm. - The standard project storm was oriented in the lower part of the basin to determine the need for supplementary flood protection after Thomaston Reservoir. Consideration was given to increasing the volume of the storm on the basis of the precipitation experienced in August 1955. However, as noted in paragraph 6 c., flood peaks in the Naugatuck River basin are a function of rainfall intensity and antecedent conditions. The intensities of the standard project storm are greater than those occurring in August 1955, hence will produce higher peak discharges. The adoption of high unit hydrographs, as described in the next paragraph, infers antecedent rainfall that saturates the ground and justifies the assumption of rapid runoff conditions.

(2) Unit hydrographs. - Unit hydrographs were derived for the gaged areas in Naugatuck Basin from investigations of floods of record. Analyses of the flood hydrographs

experienced in August 1955 resulted in unit hydrographs much larger than previously computed, thus demonstrating that peaks of unit hydrographs vary considerably with the magnitude of the flood. (See Plates B-8a and B-8b). Application of these higher unit hydrographs resulted in a greater standard project flood than derived in previous studies. Unit hydrographs for the ungaged tributaries were based on the unit hydrograph developed for Leadmine Brook, considering the difference in drainage area characteristics.

(3) Flood discharges.

(a) Natural. The standard project flood runoff from the component areas routed and combined at Naugatuck produced a maximum discharge of 138,000 c.f.s., which is about 30 percent greater than experienced in the record flood of August 1955. A major reason for this difference in magnitude is the orientation of the 2 storms. The heavier rainfall in August occurred in the upper part of the watershed while the standard project storm was located to make conditions most critical in the lower basin. A summary of the standard project flood derivation is shown on Plate B-9 with tributary and local contributions tabulated in Table B-6.

(b) Modified. In determining the standard project flood, as modified by Thomaston and the proposed reservoirs, it was assumed that the flood control reservoirs were empty at the beginning of the storm. The reservoirs would be filled during the standard project flood but spillway discharges would be minor and would not contribute to the downstream flood peaks. The standard project flood peak at Naugatuck, as modified by the proposed reservoirs, is 58,000 c.f.s., which is about 50 percent greater than the August 1955 flood modified by the same system of reservoirs. Local protection projects at damage centers, studied as part of the basin review, were designed on the basis of the modified standard project flood. As no local protection works have been found economically feasible, the standard project flood has been used primarily to demonstrate the effectiveness of the proposed reservoirs.

e. Typical tributary contribution flood. In order to evaluate the relative flood control effectiveness and the economics of projects, a synthetic flood was developed to represent a typical distribution of tributary flood contributions in the Naugatuck River Basin. The floods of record were used to determine the relative shape and timing of the component hydrographs with the peak discharge and volume related to frequency curves and average annual runoff, respectively. These component hydrographs were combined and routed, where necessary, to develop the main river hydrographs. Typical routing coefficients were selected from analyzing record floods. Tributary ogee weir in the left abutment. The reservoir at spillway crest would have an area of approximately 280 acres and would extend upstream about 1.6 miles. The reservoir would have a flood control capacity of 6800 acre-feet of storage, equivalent to 8.0 inches of runoff from the tributary drainage area of 16.0 square miles.

e. Spillway and outlet capacities. -

(1) Spillway capacities. Spillway capacities for dams in the Naugatuck River Basin have been derived in accordance with established procedure involving detailed unit hydrographs and synthetic storms of probable maximum precipitation centered over the watersheds. The data for the probable maximum precipitation have been taken from Hydrometeorological Report No. 33. Consideration was given to the need for revising this data in view of the phenomenal storm of August 17-20, 1955. It was determined, however, that for relatively small watersheds the probable maximum rainfall provides a much more severe criterion than the 1955 storm and that no revision was required.

Unit hydrographs were derived from all applicable flood records in the basin, and for adjacent rivers where watershed characteristics were comparable. Plates B-8a and B-8b are summary sheets of unit hydrograph analysis for the U.S. Geological Survey gaging stations near Thomaston Dam. The unit hydrographs from the August 1955 flood were adopted with the unit hydrograph for Leadmine Brook, adjusted for drainage area differences used to develop the spillway design flood for the ungaged tributaries. Due to the high peak values and short period of concentration, it was considered that these unit hydrographs would give conservative estimates for developing spillway design flood inflows. The hydrographs of the spillway design floods were derived by correlating the rainfall excess (assuming losses to be 0.05 inches per hour) with the adopted unit hydrographs.

The spillway design floods were routed through surcharge storage, assuming outlets operative, to determine various lengths of spillway versus surcharge elevations. The selected length of spillway and corresponding surcharge was based on the most economical combination. Freeboard requirements were computed for each dam based on fetch criteria and an assumed wind velocity concurrent with maximum surcharge. In general, a minimum freeboard of five feet has been used to determine the top elevation of the non-overflow sections of the dam. Pertinent data for the spillways are included in Table B-7.

(2) Outlet capacities. - Outlet sizes were selected to satisfy the following criteria: (a) obtain outlet discharges equivalent to the downstream safe channel capacity with a pool elevation corresponding to 20 percent of the reservoir storage, (b)

permit emptying the reservoir in a reasonable period of time, and (c) provide adequate diversion capacity during construction. The sizes of ungated outlets were tentatively selected to maintain channel capacities with a reservoir stage slightly below spillway crest.

The type of outlet selected for each dam was based on the type of dam, site limitations, and economics. The number and size of gates were selected to provide flexibility during all operating conditions and provide sufficient capacity to satisfy the preceding outlet criteria with 1 gate inoperative. Discharge rating curves were determined by conventional methods of evaluating head losses for friction, entrance, gate slots, and transitions in terms of the velocity head at the portal. Pertinent data for the outlets are also shown in Table B-7.

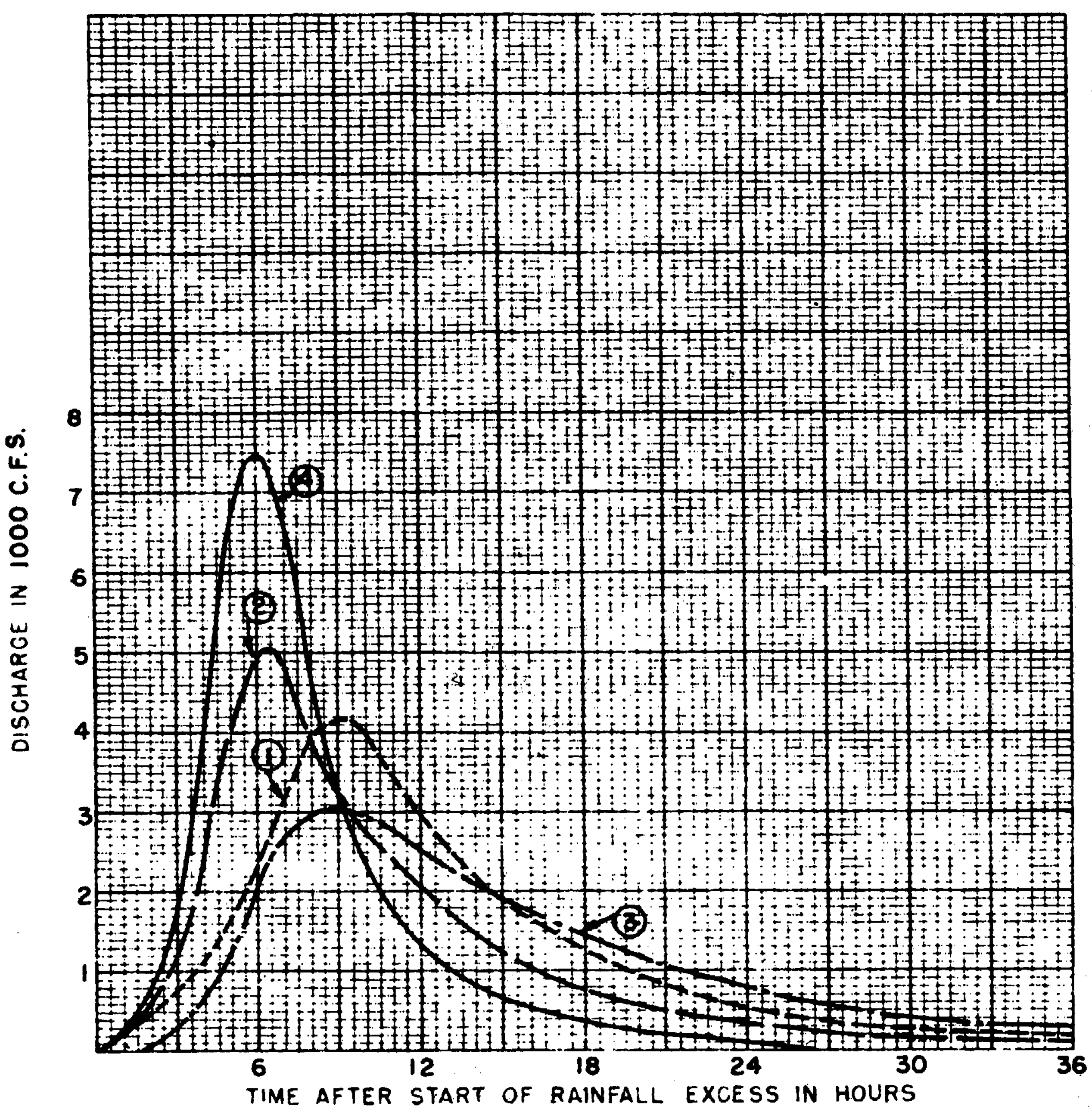
f. Effect of flood control plans. The effectiveness of each reservoir, acting alone or in various combinations with Thomaston was determined as measured by the TTCF. The final recommended system was tested by the flood of record and the Standard Project Flood. Table B-8 is a summary of the natural and modified river stages and discharges for various floods as modified by Thomaston alone and the comprehensive system at principal damage centers.

g. Reservoir regulation. The Hall Meadow Brook and East Branch Reservoirs in the upper Naugatuck River Basin will be operated primarily for the City of Torrington. The other reservoirs will be operated as a system to maintain flows within safe channel capacities insofar as possible. Key index points for regulating discharges will be Waterbury, Naugatuck, and Ansonia. The reservoirs at Northfield Brook and Hancock Brook would be ungated and will act as simple retarding basins. Control gates in the other structures will be partially or completely closed whenever the flows at the index points are expected to exceed the channel capacities. Actual regulation experience will be required to determine the safe channel capacities which are tentatively estimated as follows:

Location	Estimated channel capacity in c.f.s.
Waterbury	10,000
Naugatuck	15,000
Ansonia	18,000

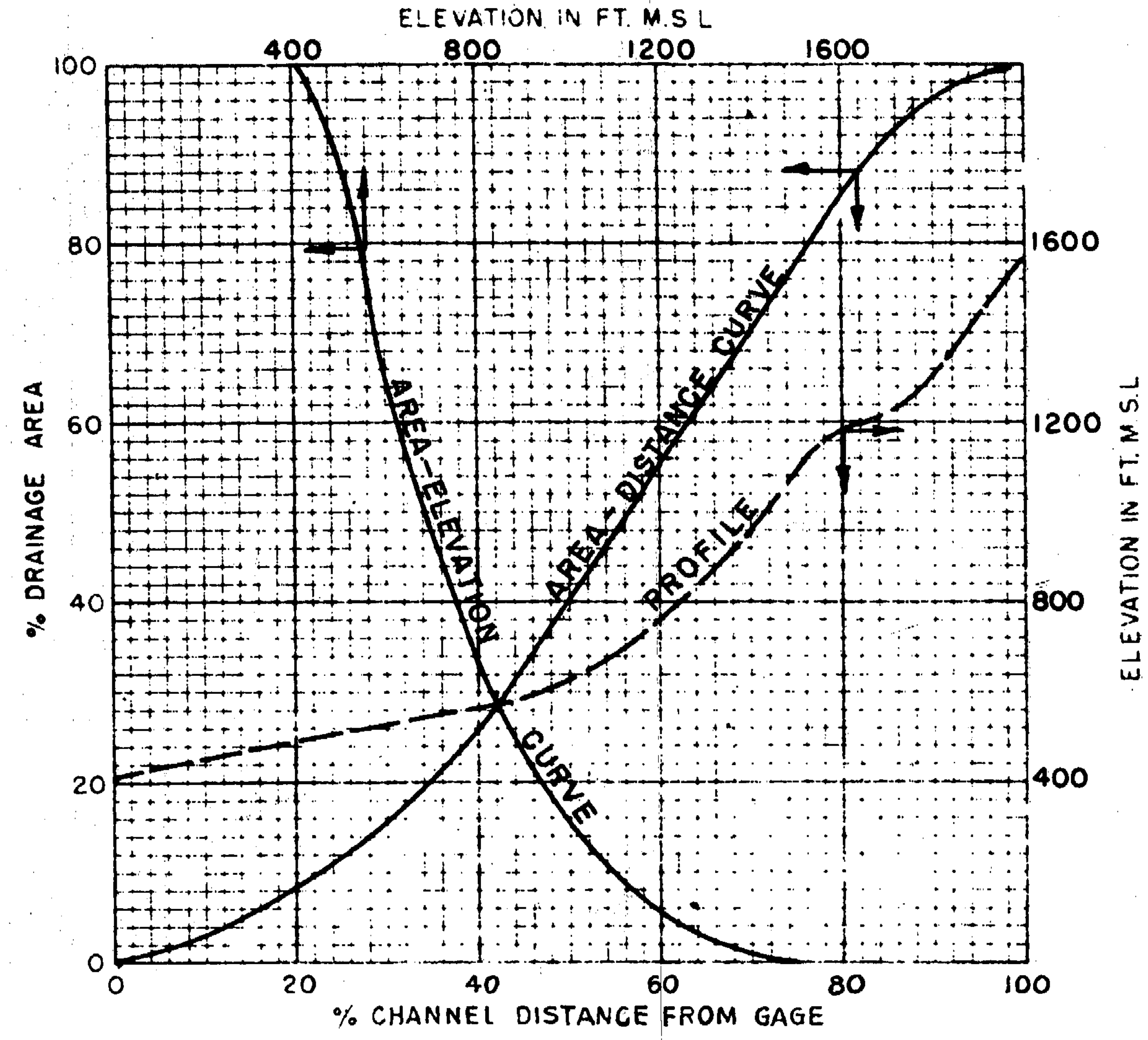
Plates B-5, B-6, and B-9 show the effect of the proposed regulation on the floods of December 1948 and August 1955 and standard project flood. The regulation of the reservoirs is demonstrated in Plate B-10 which shows the operation for the standard project flood. Some spillway discharge would have occurred but this discharge would

OBSERVED UNIT HYDROGRAPHS



DRAINAGE AREA CHARACTERISTICS

DRAINAGE AREA 71.9	sq. mi.	L	19	mi.
MAXIMUM ELEVATION 1550	ft m s l.	L_{ca}	9	mi.
MINIMUM ELEVATION 405	ft. m s. l	$(LL_{ca})^{0.3}$	4.67	
MEAN ELEVATION (weighted) 680	ft. m s l.	DRAINAGE DENSITY		mi/sq. mi
LAND SLOPE	ft./mi	MAP SCALE		
MAIN STREAM SLOPE 27.4	ft./mi	METHOD OF FLOW SEPARATION		
		BASIN SHAPE FACTOR		



DATA FROM OBSERVED UNIT HYDROGRAPHS

DATE OF RAINFALL	LEGEND	AVE. P (in.)	RAINFALL EXCESS DURATION (hr.)	RAINFALL EXCESS AMOUNT (in.)	L_{cP} (mi)	STAGE RECORD	Q_{pR} (cfs.)	Q_p tr= hrs. (cfs.)	t_{pR} (hr.)	t_p (hr)	t_v (hr.)	C_{tR}	C_p640	K_m (hr)	T_c (hr)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
SEPT. 1938	----- 1	6.71	3	1.56		REC.	4145	4145	6.33	7.5	8.3	1.36	365		
NEW YEAR 1949	— — — 2	8.15	6	1.75		REC.	3810	5070	5.0	4.0	8.0	1.16	265		
JUNE 1952	— - - 3	3.47	3	0.67		REC.	3060	3060	6.0	7.5	10.5	1.28	252		
AUGUST 1955	——— 4	13.3	6	5.6		REC.	5440	7500	4.5	3.0	6.3	0.96	340		

HOUSATONIC RIVER FLOOD CONTROL

NAUGATUCK RIVER BASIN

UNIT HYDROGRAPHS

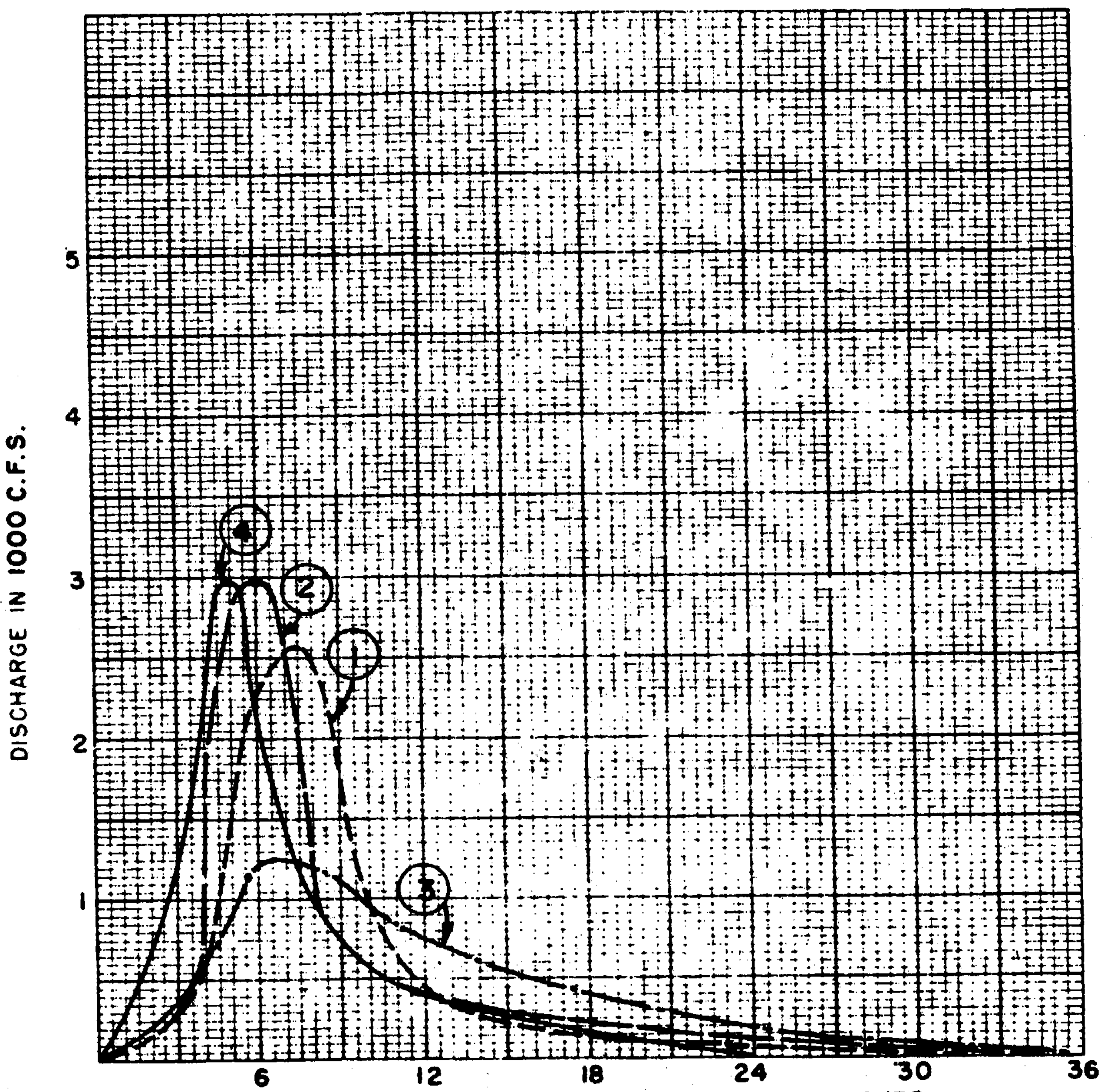
NAUGATUCK RIVER NEAR THOMASTON, CONN.

PERTINENT DATA

NEW ENGLAND DIVISION BOSTON, MASS.

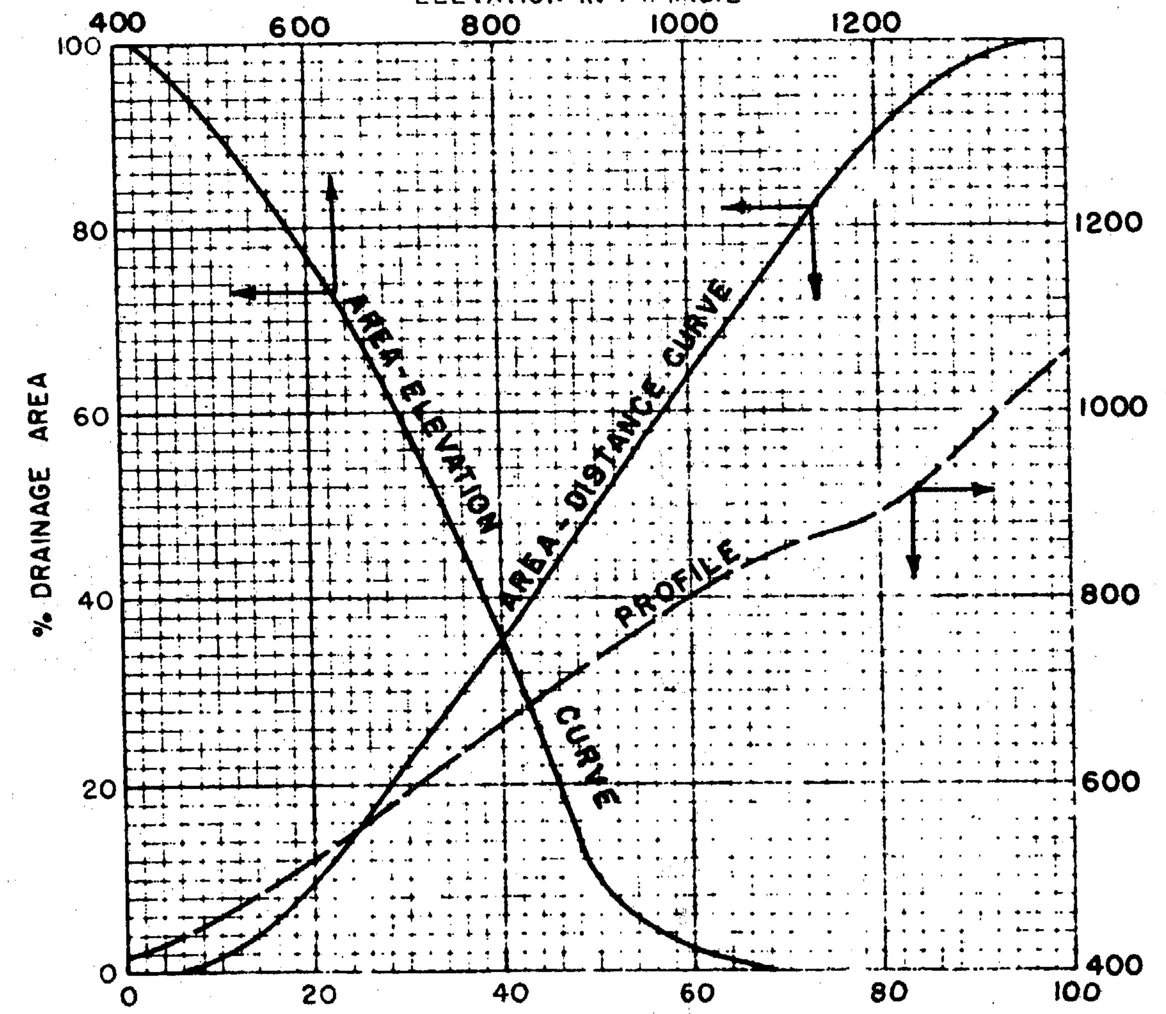
DECEMBER 1956

OBSERVED UNIT HYDROGRAPHS



DRAINAGE AREA CHARACTERISTICS

DRAINAGE AREA 24	sq mi	L	11 mi
MAXIMUM ELEVATION 1070	ft m.s.l.	L_{ca}	5.2 mi
MINIMUM ELEVATION 420	ft m.s.l.	$(L L_{ca})^{0.3}$	3.37
MEAN ELEVATION (weighted) 740	ft m.s.l.	DRAINAGE DENSITY	mi/sq.mi
LAND SLOPE	ft/mi	MAP SCALE	
MAIN STREAM SLOPE 54	ft/mi	METHOD OF FLOW SEPARATION	
		BASIN SHAPE FACTOR	



DATA FROM OBSERVED UNIT HYDROGRAPHS

DATE OF RAINFALL	LEGEND	AVE. P (In.)	RAINFALL EXCESS DURATION (hr.)	RAINFALL EXCESS AMOUNT (In.)	L_{cP} (mi.)	STAGE RECORD	Q_{pR} (cfs.)	Q_p tr= hrs (cfs)	t_{pR} (hr.)	t_p (hr.)	t_v (hr)	C_{tR}	C_p640	K_m (hr)	T_c (hr)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
SEPT. 1938	1	202	3	1.83			2550	2550	4.95	6.0	5.3	1.47	525		
NEW YEAR 1949	2	1.81	6	1.47			2850	3000	2.99	3.0	5.4	0.89	356		
JUNE 1952	3	3.47	3	0.46			1161	1250	5	5.5	8.0	1.50	242		
AUGUST 1955	4	13.5	6	3.48			2315	3000	3.79	2.0	3.5	1.12	366		

HOUSATONIC RIVER FLOOD CONTROL

NAUGATUCK RIVER BASIN

UNIT HYDROGRAPHS

LEADMINE BROOK NEAR THOMASTON, CONN.

PERTINENT DATA

NEW ENGLAND DIVISION BOSTON, MASS.

DECEMBER 1956

APPENDIX C

FLOOD LOSSES AND BENEFITS

1. DAMAGE SURVEYS

Preliminary damage surveys were made in the principal flood areas of the lower Naugatuck River Basin immediately after the flood of August 1955. In view of unprecedented flood stages and damages, losses were referenced to 1955 stages. Additional surveys were conducted during 1956 to obtain damage information for flood-control reservoir studies on the principal tributary streams.

Damage surveys consisted essentially of door-to-door interviews and inspections of hundreds of residential, commercial, industrial, and other properties affected by flooding. Recorded information included extent of the areas flooded, descriptions of property, nature and amount of damages, depths of flooding, high-water references, and relationships to prior flood stages. Damage estimates were generally furnished by property owners, although some estimates were modified by the investigators if owner evaluations appeared unreasonable. Sampling methods were used by the investigators to estimate losses of small groups of similar residences which experienced the same depth of flooding. Central sources of information and other valuable information from local, State, and utility officials were used extensively to save time and reduce survey costs.

Sufficient data were obtained to derive losses for (1) the 1955 flood crest, (2) a stage 3 feet above 1955 crest, (3) the stage at which damage begins referenced to the 1955 flood crest, and (4) intermediate stages indicating sharp changes in stage-loss relationships.

2. LOSS CLASSIFICATION

Flood loss information was recorded by type of loss and by location. Loss types used were urban (residential, commercial, public), industrial, highway, railroad, and utility. Losses were recorded by main-stem reaches of the Naugatuck River downstream of the Thomaston Dam site to provide a basis for analyses of average annual losses and benefits.

Losses evaluated in the surveys were the result of tangible, primary damages. Primary losses comprise physical losses such as damage to structures, equipment, stock, and costs of repair and clean-up; and non-physical losses such as unrecoverable loss of business, wages, or production, increased cost of operation, cost of temporary facilities, and increased cost of shipment in the flood areas.

Primary losses resulting from physical damage and a large part of the related non-physical loss were determined by direct inspection of property and evaluation of losses by property owners and field investigators. Where non-physical portions of primary losses could not be determined on the basis of available data, estimates were based upon the relationship between physical and non-physical losses for similar properties in the area.

No evaluations were made of secondary or intangible damages. Secondary damages, those incurred outside the immediate flood areas under study, include such items as business loss, loss of utilities and transportation facilities, and increased cost of travel and shipment of goods.

3. RECURRING AND PREVENTABLE LOSSES

Stage-loss and stage-discharge relationships were developed to reflect the magnitude of recurring losses at varying stages of flooding above and below the reference flood. The recurring losses used in development of the stage-loss relationship reflect economic and physical changes in the area since 1955 as revealed by the damage surveys. Table C-1 shows 1955 recurring losses after reductions by Thomaston, Hall Meadow, and East Branch Reservoirs and the P.L. 685 project at Waterville-Waterbury, and the losses prevented by combined operation of the Northfield Brook, Black Rock, Hancock Brook, and Hop Brook reservoirs, together with a description of the main damage zones in the lower Naugatuck River Basin.

4. ANNUAL LOSSES

Estimated recurring losses in the main damage zones of the lower Naugatuck River Basin were converted to annual losses as a basis for determining the annual benefits to be used in economic evaluation of flood control projects. These annual loss estimates were derived by correlation of stage-loss, stage-discharge, discharge-frequency and stage-frequency relationships, and by correlation of discharge-damage and discharge-frequency relationships, to produce damage-frequency relationships in accordance with standard practices of the Corps of Engineers. Average annual losses on Northfield, Branch, Hancock, and Hop Brooks, were determined by conversion of recurring record flood losses to annual losses by an established percentage relationship. This percentage relationship was determined by averaging the percentage relationship of the annual losses, obtained by standard methods, with the record flood losses found for all damage zones in southern New England. Average annual losses remaining after Thomaston, Hall Meadow, and East Branch Reservoirs and the P.L. 685 project at Waterville-Waterbury, and after the recommended plan are shown in Table C-2. Examples of curves used for computation of annual losses and benefits are shown on Plate No. C-1.

5. ANNUAL BENEFITS

Average annual flood damage prevention benefits were derived for the main damage zones in the lower Naugatuck River Basin by determining the

TABLE C-1

RECURRING AND PREVENTABLE LOSSES - FLOOD OF AUGUST 1955 - DESCRIPTION OF MAIN DAMAGE REACHES

LOWER NAUGATUCK RIVER
(1958 price level)

Reach	Recurring Losses after Thomaston Reductions *	Losses Preventable by Northfield, Black Rock, Hancock, and Hop Brooks	Residual Recurring Losses	Description
1.	---	---	---	Thomaston Dam to Oris Manufacturing Company dam at Reynolds Bridge.
2.	$ 40,000	$ 35,000	$ 5,000	Oris Manufacturing Company dam to mouth of Spruce Brook at Waterbury town line.
3.	2,550,000	2,430,000	120,000	Mouth of Spruce Brook to American Brass Company dam.
4.	4,915,000	2,705,000	2,210,000	American Brass Company dam to Bank Street bridge.
5.	1,890,000	1,565,000	325,000	Bank Street bridge to Platt Brothers and Company dam at lower Waterbury.
6.	4,430,000	3,135,000	1,295,000	Platt Brothers and Company dam to Beacon Falls Rubber Shoe Company dam.
7.	325,000	260,000	65,000	Beacon Falls Rubber Shoe Company dam to Seymour Manufacturing Company dam.
8.	2,615,000	1,425,000	1,190,000	Seymour Manufacturing Company dam to headwater of American Brass Company dam at Seymour.
9.	8,155,000	4,645,000	3,510,000	American Brass Company dam to tidewater at Division Street bridge on Derby town line.
10.	3,640,000	1,665,000	1,975,000	Downstream of Division Street bridge and including tidewater zone on the Housatonic River downstream of Shelton Canal Company dam.
TOTAL	$28,560,000	$17,865,000	$10,695,000	

*Includes reductions by Hall Meadow and East Branch Reservoirs and by P.L. 685 project at Waterville-Waterbury.

difference between average annual loss after discharge reductions by Thomaston, Hall Meadow, and East Branch Reservoirs and the P.L. 685 project at Waterville-Waterbury and those remaining after construction of four reservoirs on Northfield, Branch, Hancock, and Hop Brooks. Because of the very high percent reductions of discharge on the tributaries, the reservoir projects obtain average annual benefits equal to the average annual losses. Table C-3 presents a summary of the average annual flood damage prevention benefits realized by the individual projects in the reservoir system, as well as the annual benefits for each project acting last in the system of reservoirs.

TABLE C-2

RESIDUAL AVERAGE ANNUAL LOSSES
(1958 price level)

Zone	Average Annual Losses after Thomaston Reservoir Reductions*	Residual Average Annual Losses after Recommended Plan
1	-	-
2	$ 1,000	$ -
3	81,000	21,000
4	174,000	48,000
5	38,000	9,000
6	153,000	50,000
7	25,000	11,000
8	81,000	35,000
9	211,000	105,000
10	244,000	180,000
Tributaries	90,000	-
Total	$1,098,000	$459,000

*Includes reductions by Hall Meadow and East Branch Reservoirs and the P.L. 685 project at Waterville-Waterbury

TABLE C-3

TOTAL FLOOD DAMAGE PREVENTION BENEFITS
(1958 Price Level)

BENEFITS TO PROJECTS IN SYSTEM*

Projects	No Priority to Projects	Project as Last in System
Northfield Brook	$120,000	$107,000
Branch Brook	225,000	183,000
Hancock Brook	153,000	118,000
Hop Brook	141,000	116,000
Total	$639,000	

*After reductions by Thomaston, Hall Meadow and East Branch Reservoirs and the P.L. 685 project at Waterville-Waterbury.

(R 11/1/58)